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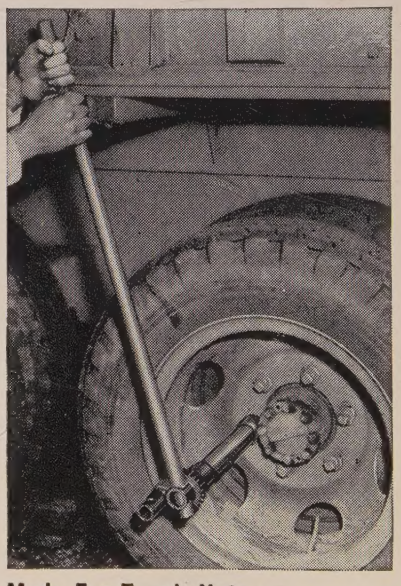

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But in case you forgot or didn't make any, here's a few good little items to remember whether you are an old hand at this game or still wet behind the ears in college.

1. As an engineer, the world is at your feet, but you need a little more than your technical knowledge to do more than get by. Take another look at the Liberal Arts courses for your non-tech electives and take a writing, lit or humanities course to improve your expression and thought processes and expand your vistas.

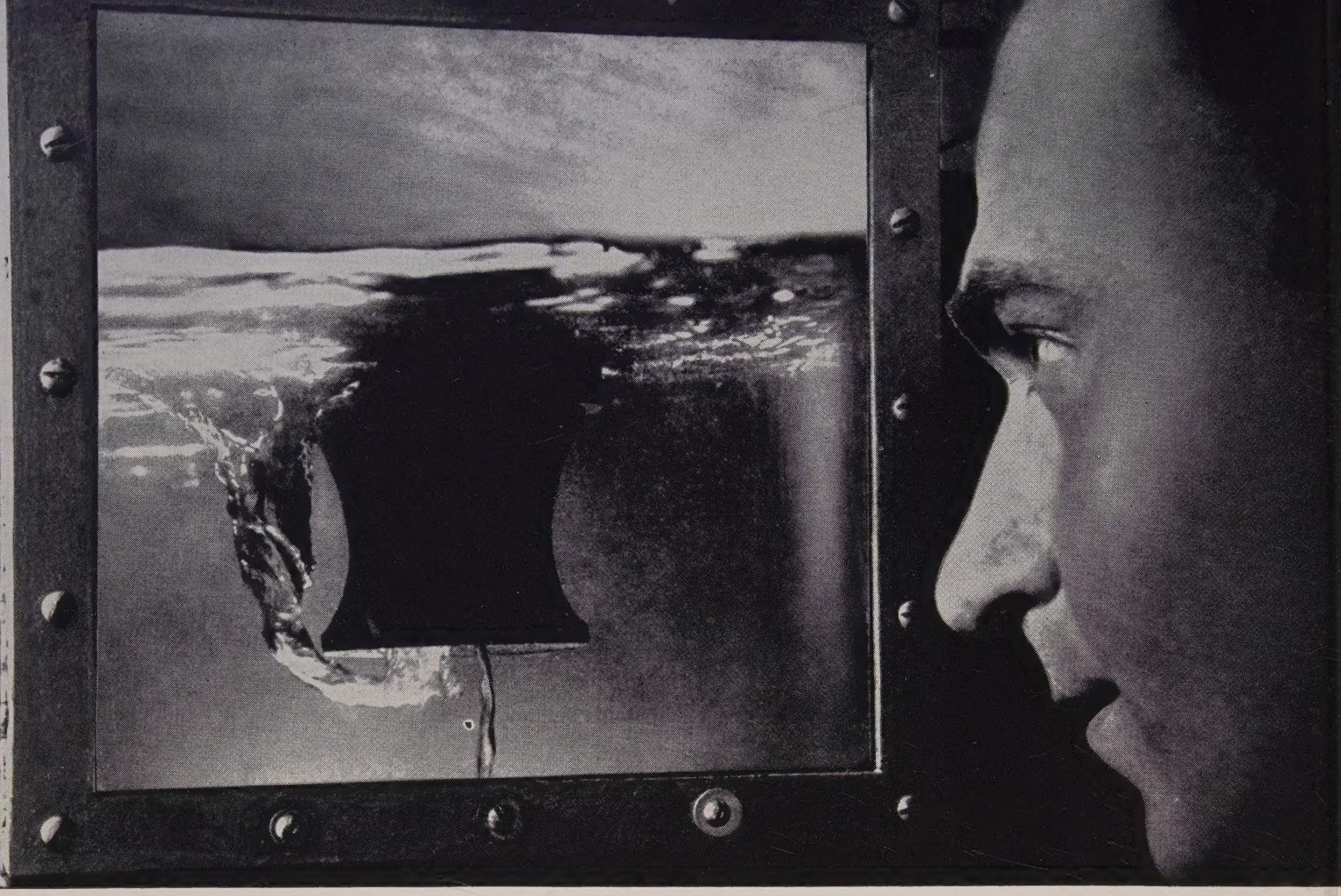
2. Get on the ball and join your professional society to see what's going on in your field and swap notes with your colleagues.

3. Join some group that may not even have a thing to do with engineering to meet more people and on a basis other than that found in classrooms, coffee-shops or Bidwell's

4. Subscribe to ye olde TECHNOGRAPH to see what's happening in the world of engineering without having to write a resume about it after reading it.

5. Drop by our office in 213 C. E. Hall. We're always around and have room for new staff members, but we won't bully you into signing something if you just want to chat.

—H. H.



A WHIRLPOOL SPIRALS into the inlet of a model pump. This unique picture shows how air, a common cause of pumping trouble, was carried into the pump in . . .

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blished eight times during the year (Ober, November, December, January, Febru, March, April and May) by the Illini blishing Company. Entered as second class tter, October 30, 1920, at the post ice at Urbana, Illinois, under the Act March 3, 1879. Office 213 Engineering ll, Urbana, Illinois. Subscriptions $1.50 r year. Single copy 25 cents. Reprint
hts reserved by *The Illinois Technograph*.
blisher's Representative—Littell Murrayrnhill, 605 North Michigan Avenue, Chigo 11, Ill. 101 Park Avenue, New York New York.

THE ILLINOIS TECHNOGRAPH

Volume 72 **Number 1**

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Our Cover

Clay residues of gold ores in this South African mountain and many other places of the world are being used as sources of sparsely distributed uranium. The Rohm & Hass Co.—to whom we are indebted for our cover plates—produce ion exchange resins which make the extraction of uranium and other metals profitable.

Our Frontispiece

Guglielmo Marconi, known as the father of modern wireless serves as our frontispiece figure this month. He is shown outdoors at an early demonstration of trans-Atlantic wireless techniques. His pictures and those for the article on the early history of radio are by courtesy of Harper & Bros., Publishers.

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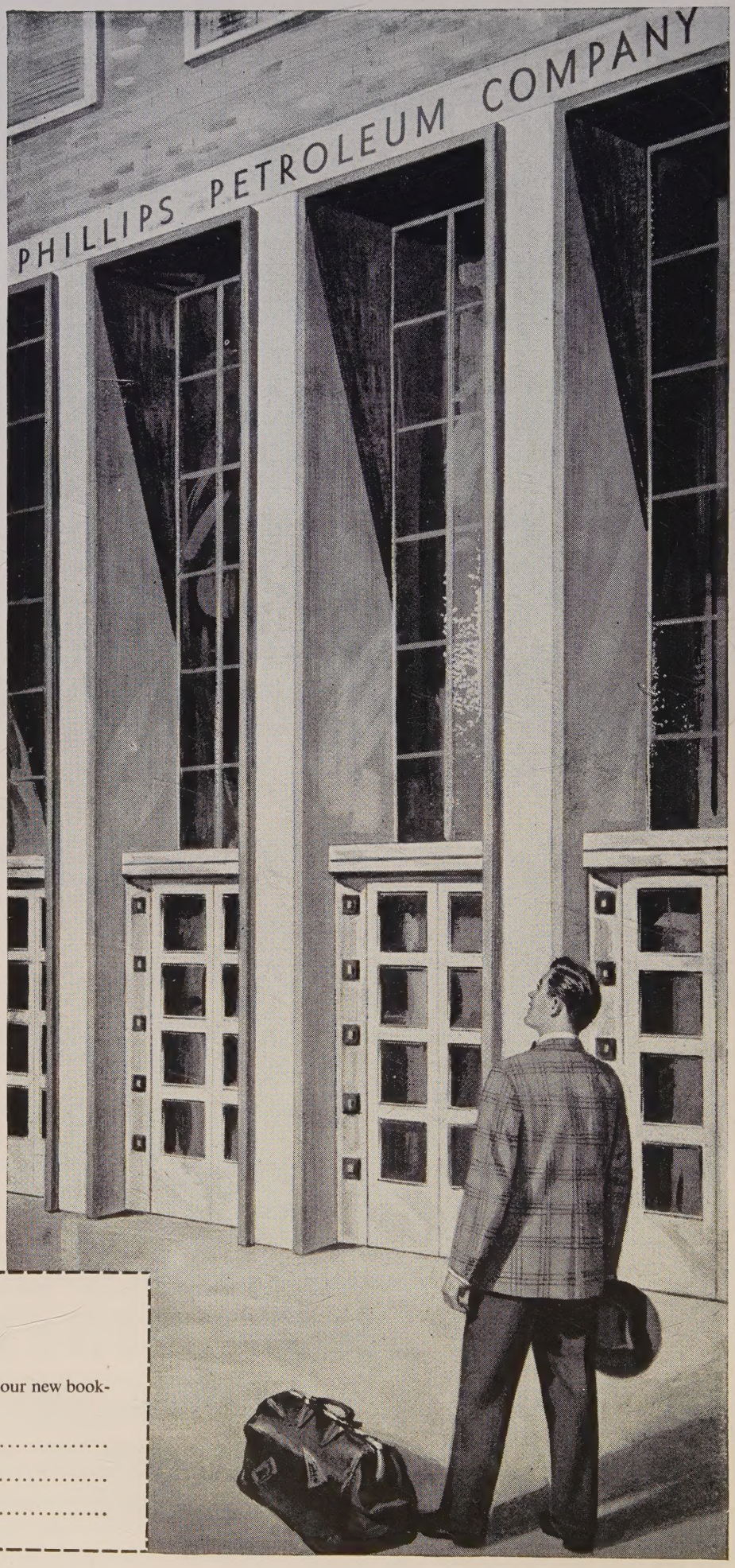

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An Early . . .

HISTORY of RADIO

by Eugene Parry, E. E. '59

Radio has now become a medium that the average person takes for granted. Like many great inventions, not one man, but many men, contributed to its development. These men ranged from amateurs experimenting in their basements on scant funds, to scientists in large corporations with everything available at their disposal.

Radio science rests on the discoveries of Ampere, Oerstad, Faraday and Henry. Between 1867 and 1873, James Clark Maxwell, a Scottish physicist, unified this knowledge into mathematical equations that showed that an electromagnetic wave is formed in the space surrounding a wire carrying an increasing or decreasing current. This theory was tested in 1887, by Heinrich Hertz, who found that electromagnetic waves were set up around an oscillating circuit, which was made up of a coil in series with a condenser and spark gap. He detected the waves by holding a hoop, containing a spark gap, some distance away from the other spark gap. In a darkened room, a spark could be detected across the gap of the hoop at a distance of several hundred feet. Hertz also found that these waves could be refracted or focused by metallic mirrors. He did other experiments and found that the waves act similar to light waves and travel at a speed of 186,000 miles per second.

Edison was among the first to attempt to use this principle for a practical purpose. In 1885, he devised a system for sending telegraph messages to moving trains by means of the regular telegraph wires along the track, and a tinfoil plate on top of the train. The idea worked—all too well in fact, because it not only picked up messages intended for it, but also any other messages that were on the nearby telegraph lines. That same year, Sir William Preece accomplished wireless communication over a distance of one-quarter mile by using two squares, 440 yards on a side, for antennas, and transmitting speech between them by induction.

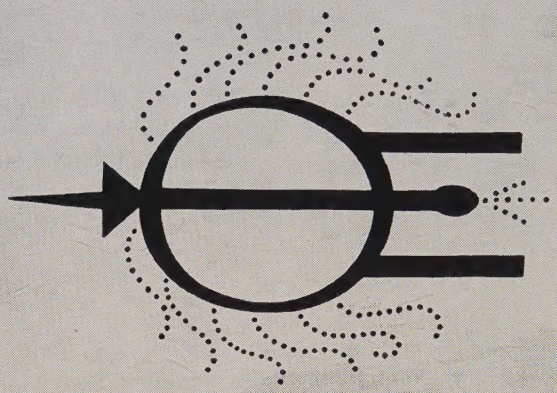
In 1890, Edouard Branly developed the coherer, a device that made it possible for electromagnetic waves to operate a telephone receiver or a telegraph relay. In 1894, Lodge improved this device, putting loose metallic filings in a glass tube. By replacing Hertz's loop receiver with a receiver using this coherer, Lodge was able to achieve a greater degree of sensitivity than was before possible. In 1895, Alexander Popoff improved the device and sent a signal a distance of 600 yards.

In 1895, Guglielmo Marconi, probably the greatest single contributor to the development of radio, transmitted and received a wireless signal over a distance of three-quarters of a mile. The system he had set up on his father's estate at Pontecchio, near Bologna, Italy, used both an aerial and a ground connection—the first time such a system had been used. He continued his work (he was only 21 when he started), striving for greater distances. After many more tests, each one at a greater distance, he was able to telegraph across the Bristol Channel, a distance of over eight miles. The next year he sent a message 18 miles, and soon after he sent messages from St. Catherine to Poole, a distance of 30 miles. On this last successful attempt he used tuned apparatus that enabled him to send two messages simultaneously from two transmitters to two receivers. He accomplished communication across the English Channel in 1899, and in 1901, he succeeded in transversing the Atlantic, transmitting from Poldu, Cornwall, England, to St. John's, Newfoundland, a distance of 2,000 miles. He used an antenna suspended from a kite to receive the first trans-Atlantic message—the letter "S" in Morse code (three dots).

In 1896, Marconi assembled equipment developed by himself and others, and approached British interests, proposing the use of Hertzian waves for commercial communications. The Wireless Telegraph and Signal Co., was formed for this purpose in 1897. Its name was changed to Marconi's Wireless Telegraph Co., Ltd. (commonly called the British Marconi) in 1900. Later, when Marconi came to the United States, he formed the Marconi Wireless and Telegraph Co. of America, which was owned by the British Marconi. The American Marconi did not operate high power stations for trans-oceanic transmissions until 1912, when stations were constructed to give radio service to ships. There were 60 land stations constructed on the Atlantic and Pacific coasts for this purpose.

At the same time he was developing the business end of radio, Marconi was continuing to work on the technical aspect of the field. Between 1897 and 1899, he developed his tuning apparatus, for which he received a patent in 1900—the basic patent of the radio art for 17 years. His early system had consisted of a battery, key, spark coil and spark gap (one end of which was connected to ground, the other to a capacity plate) for a transmitter, and a battery, coherer, Morse sounder, and ground and capacity plate for a receiver. After the development of his tuning apparatus, Marconi's transmitter had a series condenser and inductance (coupled to another inductance connected to an antenna and the ground) connected in parallel with the spark gap: his receiver replaced the coherer with a detector, and contained a tuned circuit consisting of a condenser, inductance and antenna and ground system. It was this improved circuit that made possible the simultaneous transmission of two signals, as he used when he transmitted from St. Catherine to Poole.

There were several other less-known experimenters working on the problem of wireless about the same time as Marconi. One of these was Prof. Reginald Fessenden, who was the first important American inventor to experiment with wireless. In December, 1900, Fessenden gave a demonstration to the Weather



صفة بيضة تخرج وتخرق

er-Rammah's self-moving egg

Join two flat pans; fill with an incendiary mixture; add a tail; propel by two large rockets. In A.D. 1280, Arabia's Hassan er-Rammah, gazing centuries ahead, proposed this ovoid in his "The Book of Fighting on Horseback and with War Engines."

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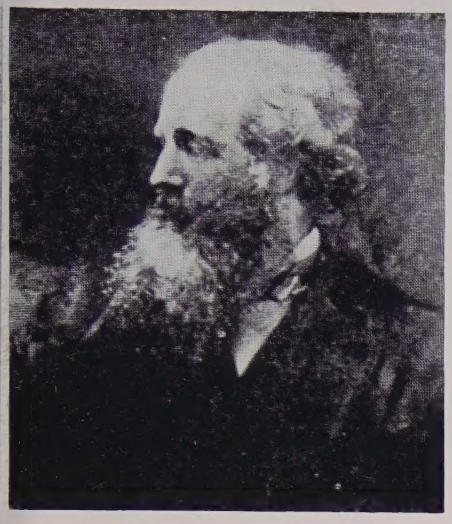


JAMES CLARK MAXWELL
Unified previous knowledge

Bureau in which he transmitted speech by Hertzian waves, using two masts 50 feet high and one mile apart. The speech, however, was unsatisfactory and the distance too short to be of practical value—the tests were useful scientifically, nevertheless.

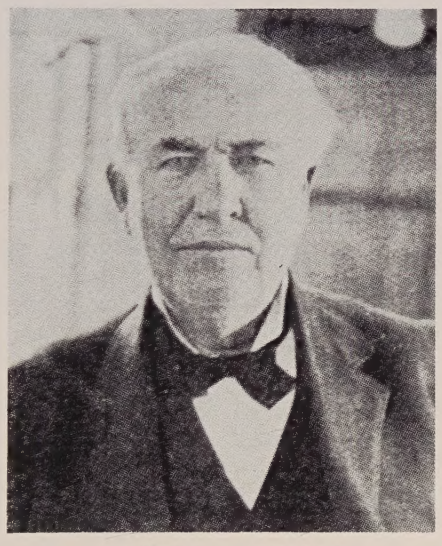
In 1906, Gen. H. N. C. Dumwoody discovered the rectifying qualities of carborundum crystals; the same year, Greenleaf Pickard discovered similar qualities in silicon crystals. These crystals were used as detectors in early receivers.

Another invention that helped greatly in the improvement and development of radio is the vacuum tube. In 1883, Edison inserted a metal plate in with the filament of his lamp. When he connected the positive pole of a battery to the plate, and the negative pole to the filament in the lamp, and then applied current from another source to light the filament, he discovered that a current flowed between the elements, although there was no connection between them. Furthermore, when he switched the battery connections, he was surprised to find that this time, current did not flow. John Tompson, in 1899, explained this phenomenon as a motion of electrons from the negative to the positive element. John Fleming, in 1905, improved on Edison's discovery by putting in a metallic cylinder in place of the flat plate. By doing this, he created a diode, which he called a thermionic valve, that made receiving arrangements more reliable and sensitive.

In 1906, Lee De Forest found that by adding a grid of fine wires between the filament and plate of the tube, the tube was then capable of creating oscillations and amplifying and detecting radio waves. In 1908, De Forest broadcast phonograph records from the Eiffel Tower in Paris—he was heard as far away as Marseilles. The American Telephone and Telegraph Co. later acquired the De Forest patents and developed circuits using his audion (the name given his tube). Working with Western Electric in 1915, AT & T accomplished long-distant wireless telephony from Arlington, Virginia, to Hawaii.

A principle that was quite ingenious, but was discovered before its time, was the heterodyne system, which was devised by Fessenden around 1905, but not used until Maj. Edwin Armstrong developed from it his superheterodyne circuit. Fessenden's device took two initially high frequencies and electrically subtracted them, giving a difference which fell in the audible range.

Probably the first practical use for wireless was communications with ships. In 1909, the "Republic" sank in Long Island Sound with Jack Binns at the key. In 1912, when the "Titanic" struck an iceberg on its maiden voyage, aid was summoned by calls over the radio by operator Jack Irwin. There were many other cases in which many lives were saved because of the existence of radio communications on board ship.



THOMAS A. EDISON
Vacuum tube inventor

One group that has done much for the advancement of radio is the radio amateurs. In the 1920's Lee De Forest said to H. P. Maxim, president of the American Radio Relay League at that time:

"Had it not been for the radio amateur, there could have been no radio broadcast and no radio industry as it exists today."

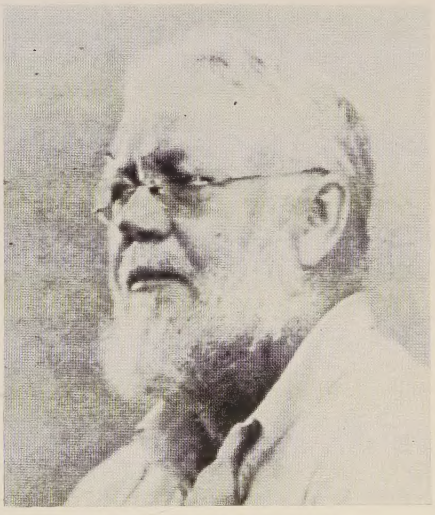
Up to 1914, amateur radio operators were unorganized and had little power to defeat legislation detrimental to their cause. In 1914, Hiram Percy Maxim devised the idea of an organization of relay stations all over the United States, to make it possible to send messages long distances; Maxim formed the American Radio Relay League, which is still a strong organization today.

Maj. Edwin Armstrong, a radio amateur, discovered the regenerative (feedback) circuit in 1914; during World War I, he developed the superheterodyne circuit. In 1923, when he wanted to sell ideas to RCA, he walked out of the elevator into the meeting with the RCA executives with a radio under his arm playing opera—without a visible antenna on the radio. This amazed the officials and the regenerative circuit was received with open arms.

The "hams" proved the value of low power short-wave, by spanning the Atlantic in December, 1921 on 200 meters. In November, 1923, amateurs accomplished the first high frequency communication across the Atlantic by using a wavelength of 100 meters.

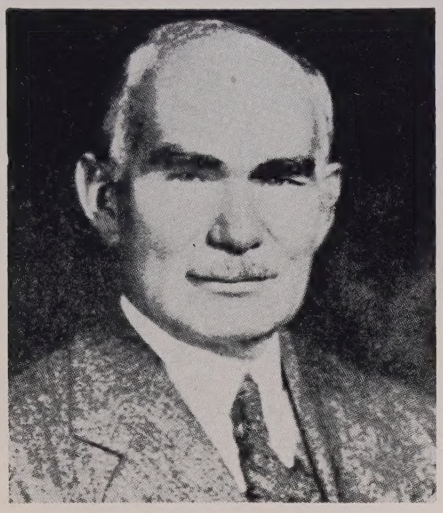
In 1927 new restrictions, which went into effect Jan. 1, 1929, were imposed on the hams by the United States government. These revisions required a large amount of revision in the present equipment used by the hams. To meet the deadline, so that amateur operators could stay on the air, the A.R.R.L. formed a technical development program, headed by Ross Hull. Hull and a small group of assistants compressed years of research and development into a few months. They made vast improvements on the equipment, and, when the deadline came, most hams were equipped to comply with the new restrictions. In the course of his work, Hull made many improvements which also helped short-wave communication in other fields. Ross Hull also worked on the transmission of very high frequencies in what is now the television range.

Many men saw the possibility of also using radio for home entertainment rather than just as a means of communications. One of the first programs, heard



REGINALD FESSENDEN
American wireless innovator

mainly by ships' radio operators was transmitted by Fessenden in 1906. Fessenden broadcast a Christmas program of music and speech as an experiment. In 1909, Fessenden accomplished the first long-distant speech broadcast. In 1914, music from phonograph records was



LEE DEFOREST
Father of modern radio

broadcast by the radio station at Wanamaker, N. Y., to anyone who had a receiving set—which at that time included the government departments, commercial radio companies, and amateurs. During and after the war, there were several more broadcasts.

In August, 1915, David Sarnoff proposed the idea of radio broadcasting to his management, the Marconi Wireless Telegraph Co. of America. He predicted the day would come when all homes would have "radio music boxes." In 1920, Sarnoff, now the commercial manager of RCA, again suggested radio broadcasting on a full-time basis. He estimated that if RCA began broadcasting and making home receivers, in three years it would be able to sell one million radios, aggregating $75,000,000. RCA took his suggestion: the total sales of radios in 1922, 1923, 1924 totaled $83,450,000.

Shortly after the ban on amateur radio was removed, Frank Conrad, of Westinghouse, rigged up a spare time research station from which he sent out phonograph music and baseball scores. He was surprised, in the spring of 1920, to find many other hams had been listening to his programs. A Pittsburgh newspaper heard of this fact and carried an advertisement for radio equipment "to be used by those who listen to Dr. Conrad's programs." After this appeared, Westinghouse officials, with the idea of stimulating the sale of their supplies, decided to open the first full-scale broadcasting station in history. In 1921, Frank Conrad established station KDKA at East Pittsburgh.

The station made slow headway at first. Its first broadcasts were phonograph records and news. Soon after it tried a full orchestra and found that the resonance of the room spoiled the effect; then it moved to a tent on the roof, but the tent blew away. Next a tent was pitched in a large room and it was found to be an effective solution. Later it was discovered that cloth hangings, which are still used, muffled the sound correctly.

In 1921, the Department of Commerce licensed 32 radio broadcasting stations in the continental United States. All types of broadcasts came into being. Dr. Van Etten, of Pittsburgh, permitted the services at Calvary Church to be broadcast. Market reports, radio concerts, and political speeches went over the airways. A San Francisco newspaper stated:

"There is radio music in the air, every night, everywhere. Anybody can hear it at home on a receiving set, which any boy can put up in an hour."

In February, 1922, President Harding had an outfit installed in his study, and the Dixmoor Golf Course announced it would install a "telephone" to enable golfers to hear church services. The retail value of radio sets, parts and accessories, went from $60,000,000 in 1922 to $842,000,000 in 1929.

In 1922, the first commercial program was broadcast by WEAH, the station owned by AT & T. In October, 1923, the first station hook-up for simultaneous broadcasting was established between WEAF, New York and WJAR, Providence. Early listeners remember the famed "24 votes for Oscar W. Underwo--od," when Alabama deadlocked the Democratic National Convention at New York. This broadcast, headed by WEAF, had the largest hook-up to date. In September, 1926, RCA brought WEAF from AT & T and formed the first network organization—the National Broadcasting Co. NBC started broadcasts on Nov. 15, 1926, with 24 stations in 21 cities, extending from the Eastern seaboard to Kansas City. It presented the first coast-to-coast network broadcast on New Year's Day, 1927: a play-by-play broadcast of the Rose Bowl football game from Pasadena, Calif.

More networks came into being after NBC. On Jan. 1, 1927, a second NBC network was formed. To differentiate between the two, they were called the "Red network" and the "Blue network" (from the pins that engineers used to mark stations on the map.) The Columbia Broadcasting System began Feb. 18, 1927, with a basic network of 16 stations. On Oct. 2, 1934, the Mutual Broadcasting System started with four stations. Because of orders from the Federal Communications Commission, NBC sold its "Blue network," which became the American Broadcasting Co. in October, 1943. On Jan. 1, 1949, ABC had 272 stations, CBS had 179, Mutual had 519 and NBC had 170.

We have come a long way from Hertz's spark in the dark. Today color television is being perfected; high fidelity record players have become common. It would be impossible to predict what will be developed in the next few years. Three-dimensional television?—it has already been used for some special purposes. Wristwatch radios?—looking at the advertisements for transistor radios, one can see them coming. Television screens that hang like a picture?—several companies are working on that idea. Transfer of matter by radio waves?—well, not yet, but who knows? maybe

HEINRICH HERTZ
Wave experimenter

someday. At least no one can truthfully say that we have reached the ultimate possibilities of radio and electronics. There is more yet to come!

LIST OF REFERENCES CITED

Allen, Frederick L. *"Only Yesterday."* New York: Bantam Books, 1946.

Archer, Gleason L. *"History of Radio to 1926."* New York: The American Historical Society, Inc., 1938.

De Soto, Clinton B. *"Calling C.Q."* New York: Doubleday, Doran, and Co., Inc., 1941.

Dunlap, Orrin E. *"Radio and Television Almanac."* New York: Harper, 1951.

Herring, James M. *"Telecommunications."* New York and London: McGraw-Hill Book Co., Inc., 1936.

Maclaurin, William R. *"Invention and Innovation in the Radio Industry."* New York: Macmillan, 1949.

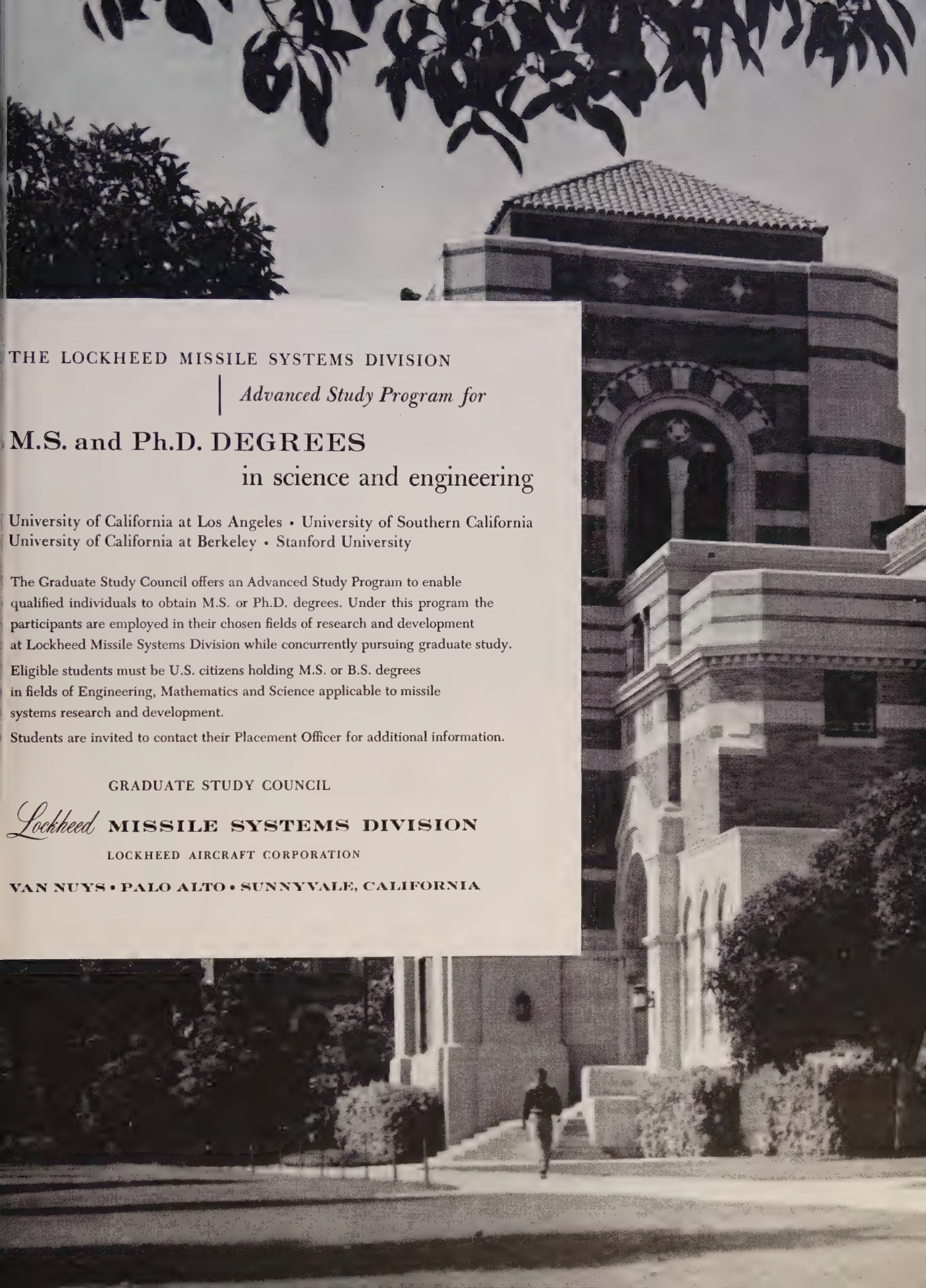
Morris, Lloyd R. *"Not So Long Ago."* New York: Random House, 1949.

"Radio," Colliers' Encyclopedia, 1955 Edition.

"Radio," Encyclopedia Americana, 1955 Edition.

"Radio," Encyclopedia Britannica, 1954 Edition.

Squier, George O. *"Telling the World."* Baltimore: The Williams and Wilkins Co.



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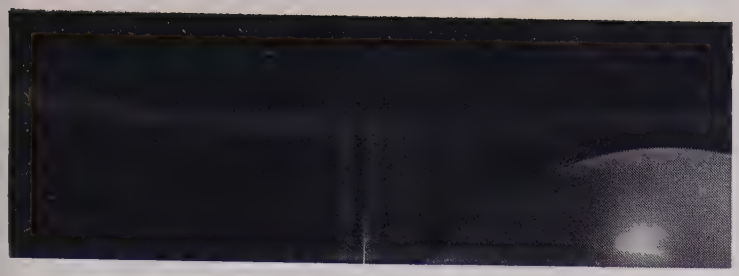
The American Monorail

by Harry Hirsch, E. E. '57

Transportation deluxe . . . as the Skyway Trailblazer coach glides over the problems of present day mass transportation—meaning dirt, danger and delay. Monorail officials say the sky coaches can travel at great speeds, but this would be determined by the convenience and needs of the passengers. (Photo by Monorail, Inc., Houston)

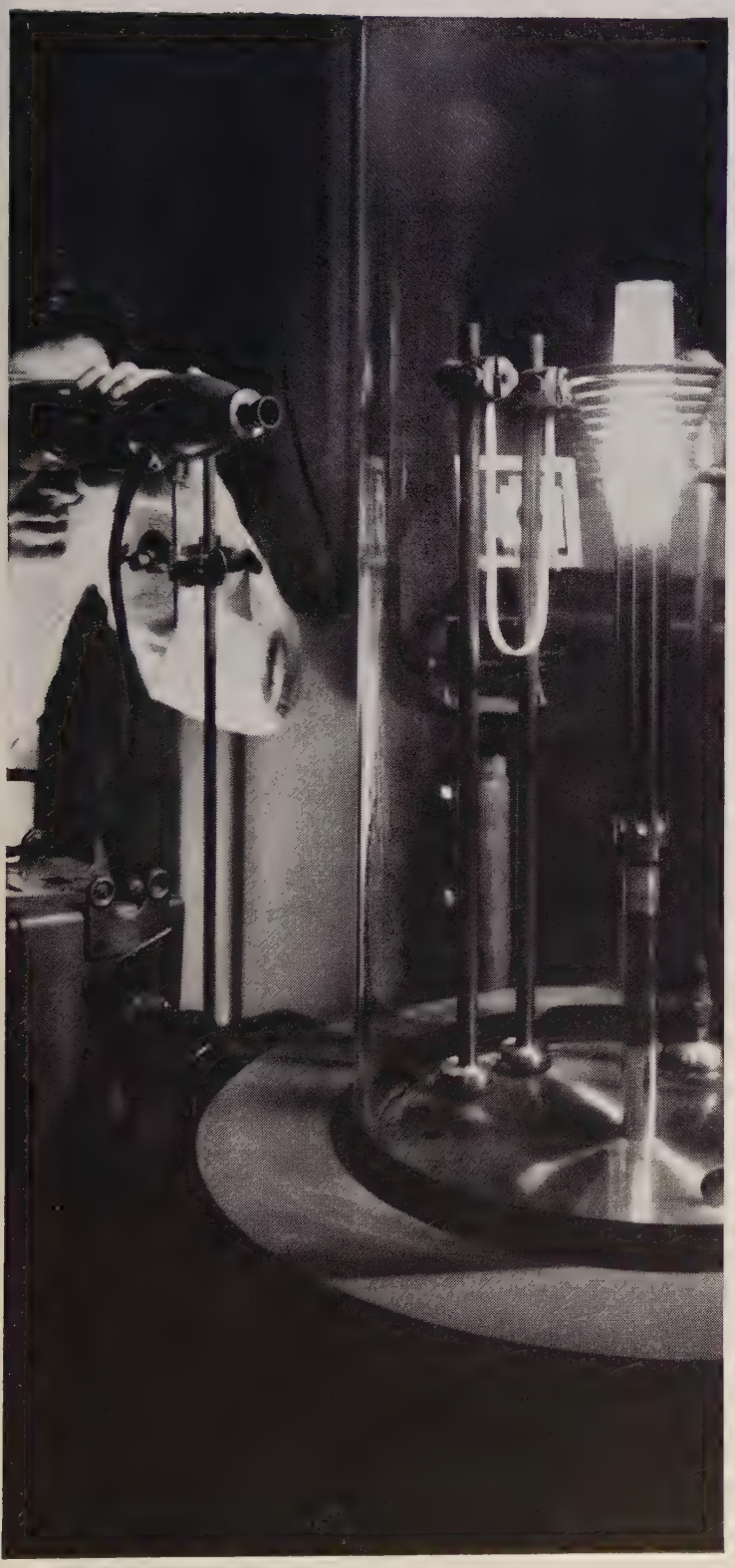
Each year as our population grows, more people are driving in more cars on streets and highways that have not grown with the rest of the nation. In the cities especially, this growth has been attended by greater and greater congestion as frustrated commuters foresake their buses and trolleys and trains for their autos and grow more frustrated. A resident of Chicago can testify to this upon seeing traffic crawl through the narrow streets of the "Loop", as the downtown business district is called. Indeed, congestion reached such a point that a special experimental lane has been set aside in one street for the use of busses only to facilitate their movement. Local gentry may not see such drastic measures, but the heavy traffic at Green and Wright Streets at 5 p.m. is bad enough to bear.

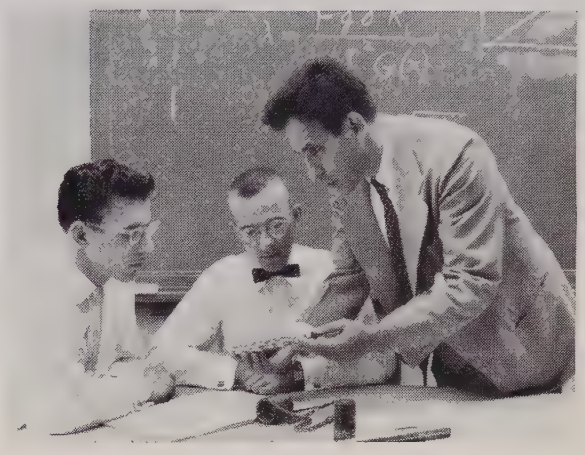
There seems to be almost a vicious circle of congestion causing people to foresake local transit to drive and add



Refining metals to perfection

...A PROBLEM IN PURITY





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Westinghouse

Elevated lines have reached the saturation point in traffic carrying ability as this Chicago rush-hour scene shows. Monorail offers a means of carrying more traffic at faster speeds with less congestion.

to the congestion. Transit officials say their vehicles moved more rapidly 25 years ago.

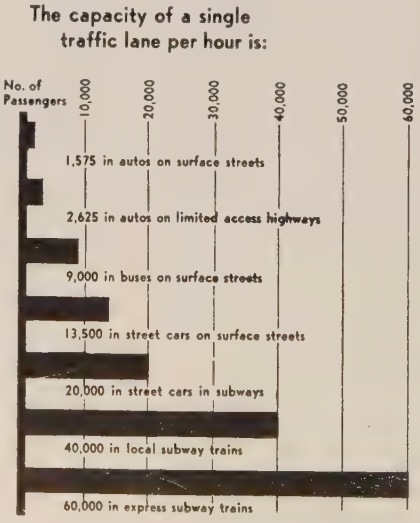
After World War 11, many cities invested in high-speed trolleys only to see their investments dragged to snails-pace by congestion and have been forced to reinvest in slower, but more maneuvable, busses.

Cities desire better, faster rapid transit to move their people faster and cut congestion, but how can they achieve this? Some cities have elevated lines, but they are noisy, unsightly and considered relics of by-gone days with their cluttered pillars. They have largely been replaced by subways in those cities which can afford subway construction. The high costs of subways are often prohibitive to their construction. Construction costs of a 1½ mile subway in Cleveland have been estimated at 35 million dollars. Another proposed rapid transit alternative is median strip operation of trains between the drives of an expressway. Chicago will have such an operation soon along its Congress Street expressway and Cleveland's Shaker Heights Rapid Transit conducts most of its operations in this fashion Rapid transit trains of high-speed street cars run along their private rights of way free from auto and pedestrian traffic.

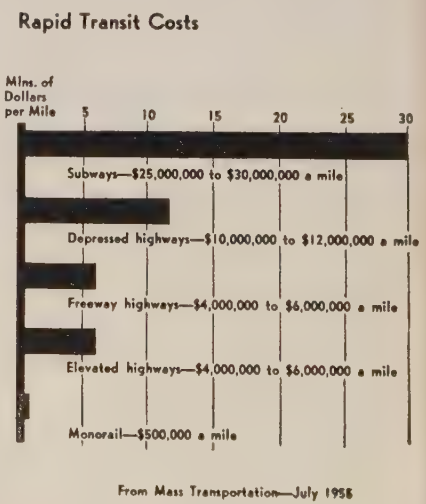
Yet another means of rapid transit, more modern, yet older than the others, more radical, yet safer than the others, has yet to be spoken of and developed. This is the monorail. Today by some experts, it is being hailed as the next logical development in mass high-speed transit. A single nine-mile operation in Germany has existed for over 50 years and carried over 310 million passengers without a fatality, but for years this operation has been the only example of monorail use. The monorail is faster than the subway and is built at a lower cost. It is cleaner and quieter than elevated operations and takes far less space. It can be built faster and much easier than any of the other forms of rapid transit.

It is hard to catalog reasons for the long-standing reluctance to accept and employ the monorail concept. At the time of its inception near the turn of the century, elevated lines of any sort were beginning to lose their appeal to the public and to transit operators. Cities were tired of the dirt and noise along their streets. The monorail, as then envisioned, was to be built along the lines of the elevated railway with street-straddling pillars to support its cars. For many years it languished on the drawing boards, while subways were built by the "cut and cover" method, which was cheap, since it involved tearing up streets for construction rather than tunneling under them as is now required by the heavy traffic in the cities. Once it became necessary to keep streets open during construction, costs skyrocketed and the subways began to be less and less easy to build. Dr. Alois Cibulka, professor of civil engineering at the University of Houston, and authority on European aerial-type tramways, said American people were not psychologically ready for such tramways, but the time would come when the need for an answer to the increasing traffic problem would call for the establishment of such a project and it would be accepted.

It has been demonstrated that monorail can achieve speeds of up to 100 mph safely. It thus has great carrying capacity. Today's monorail is carried on inverted J-beams which greatly reduce the area it covers in contrast to the double and sometimes triple columns of the elevated railways. For today's mono-


The capacity of a single traffic lane per hour is:
No. of Passengers
10,000
20,000
30,000
40,000
50,000
60,000
1,575 in autos on surface streets
2,625 in autos on limited access highways
9,000 in buses on surface streets
13,500 in street cars on surface streets
20,000 in street cars in subways
40,000 in local subway trains
60,000 in express subway trains

From bulletin issued by General Electric



From Mass Transportation—July 1958

The chart on the left illustrates the flexibility of rapid transit to carry passengers, while that on the right demonstrates cost estimates for various forms of transit.

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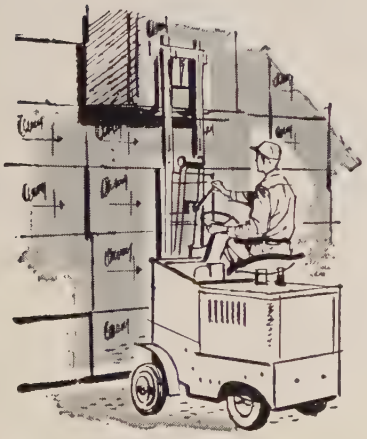

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BALL BEARINGS

NOTHING ROLLS LIKE A BALL

One solution to traffic problems is the open-cut subway such as that used by Chicago Transit Authority and the Chicago North Shore and Milwaukee Railway near Chicago. (Photos by author)

rail, slender beams set about 50 feet apart suffice to carry two directions of traffic.

Let us examine in more detail, the latest of monorail developments outside of Houston, Tex., on the site of an abandoned race track, a pilot 970 foot prototype line called "Skyway" has been built. The single car in operation is called "Trailblazer." This project grew from dissatisfaction with Houston's surface transportation and is financed by $120,000 worth of private capital. It has been estimated that full scale speeds of 60 mph can be reached on the pilot project. Monty Levine, of Monorail, Inc. as the overall operation is called, has said that a fully operating monorail can be built at a cost of $500,000 per mile, just one third the cost of a freeway and a fraction of the cost of an elevated or subway, Since the structure consists of inverted "J" shaped tower about 50 feet apart, plots of land about four feet square are all that would have to be acquired.

Skyway officals say the line can cross rough or smooth terrain, going over valleys or across rivers. It can be used for commuter service, intercity travel, or for shorter industrial or specialized purposes. The rail is designed so that the center of gravity is below the carrying rail with the coach itself suspended below the rail.

"Trailblazer," the coach, can be run equally well backward or forward with the engineer-operator turning his seat around to face the desired direction. Visibility is enhanced with the operator's cab placed above the car and rail. The 55 foot coach can be built longer or shorter depending on the needs of the operating company. It is 7 feet high and 8 feet wide inside, seating 60 and providing standing room for 50 more. Outside construction is of fiberglass "skin" stretching over approximately 3,000 square feet of coach exterior.

This is believed to be the biggest commercial use ever made of a fiberglass skin. Plexi-glass is used in the present coach, but solar-glass, due to its use in windshields and its freedom from blemishes, is planned for future models.

The four doors of the coach are placed to allow for quick passenger flow. The coach can be emptied or filled in 30 seconds. The coach weighs approximately 26,700 pounds, or about 400 pounds per passenger. This compares with 1,000 pounds per passenger on a bus and 2,000 pounds per passenger for railroad coaches. Locking wheels and locking guide rails make it impossible for the coach to leave the track. Brakes are automatic electric and the coach makes use of "dead man control" braking. If the operator takes his hands off the controls, the train stops automatically. Eight Goodyear tires are employed to guide the coach. They are of high tensile nlyon and are blowout proof. In case of emergency, eight auxiliary steel wheels are ready to take over.

Power for the present operation is provided by two 310 HP Packard engines, but the planners point out that the monorail can be easily powered by straight electric operation similar to elevated and subway lines. The rail is a pipe flattened on top with an 18 inch surface bisected by a flange of steel eight-wheel power unit with operator's about 6 inches high and ½ inch thick wheels on each side of the flange. For running down the center of the rail. The cab runs atop the rail with four drive guiding the unit and preventing weaving action, a smaller rubber tires wheel is mounted in front of each drive wheel.

This "guide" wheel is mounted horizontally to press in against the flange for guiding. The coach is suspended from the power unit by two steel semi-circles.

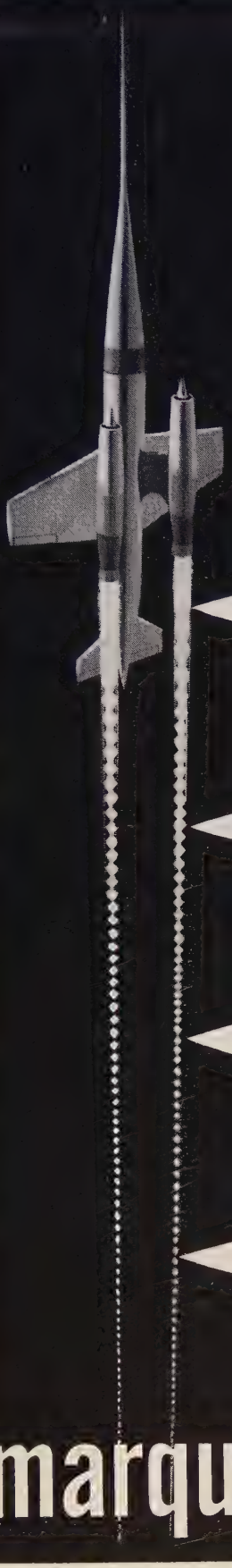
This pilot model is designed for demonstration of the uses of monorail. What is the situation outside of Houston? Reports in "Time" magazine say that Monorail Inc. and Texas Motor Coaches are considering the construction of an intercity line between Ft. Worth and Dallas, two booming Texas metropoli about 40 miles apart.

Studies are being made in California for possible monorail construction in the Los Angeles area. Costs would be about 165 million dollars for a 45 mile line and 134 million dollars for a 29 mile line. These figures include all the capitalization for the cost of a two mile downtown subway. The Los Angeles line would average 41 mph with 15 stops. New York's fastest subway runs are only 24 mph. Ten car trains with three operators are planned. It is said that car and engine replacement costs would be virtually non-existent and maintenance costs light. How far this plan will progress beyond the talking stage remains to be seen.

John C. Baines, president of the St. Louis Public Service Co., says of monorail, "I forsee an atomic powered monorail system for mass rapid transit-fed by fast, light-weight buses from 'park-ports' conveniently located along rapid transit routes by 2000 A.D."

C. T. Foster, general manager of Deleware Coach Co., says, "More rapid transit-either monorail or subway," will be used in 2000 A.D. "Streets will be allocated to transit only. Cars will not be allowed in downtown streets."

Whether these plans and predictions for utilization of monorail ever leave the drawing board or podium, whether we shall see our cities strangled to death by autos or interlaced by high-speed rapidtransit, one facet of the monorail story will remain as it has been since 1901; The German Rhuhr Valley Wuppertahl line will continue its dependable operations along its twisting 9 mile route.



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Engineering Writing

by Glenn B. Andrews, E. E. '57

Introductory Note:

Glenn Andrews worked this past summer as a writer in Technical Manuals Section of Hughes Aircraft Company, Culver City, California. This section writes and produces handbooks on the radar and missile systems Hughes develops for the Military. While at Hughes, Glenn had a chance to observe and study the unique aspects of engineering writing. In this article he presents an overall picture of technical writing, the different forms it takes, and the difficulties associated with it.

It has been said that in this age, the men of science have the most knowledge to reveal to the people, yet they are the ones that least know how to go about it.

Whereas this statement, because it goes to extremes, is of questionable validity, it nevertheless brings out one of the main problems of technical personnel; they generally lack the ability to express themselves sufficiently to their fellow scientists, their non-technical superiors, or to the general public.

There are several reasons for this problem as it now exists. One of the main causes for the inadequacy is the lack of encouragement of engineering writing in our colleges and universities. Some engineering schools have courses in engineering writing which are quite adequate, but many more fail to give it any attention other than the standard laboratory report writing.

Under the current engineering educational programs, the students learn to express themselves in three ways; mathematically, graphically, and linguistically. The competitive demands for time has limited such training mainly to mathematical symbols and graphs, unfortunately at the expense of the spoken and written word. The communication of scientific ideas depends upon both the former and the latter.

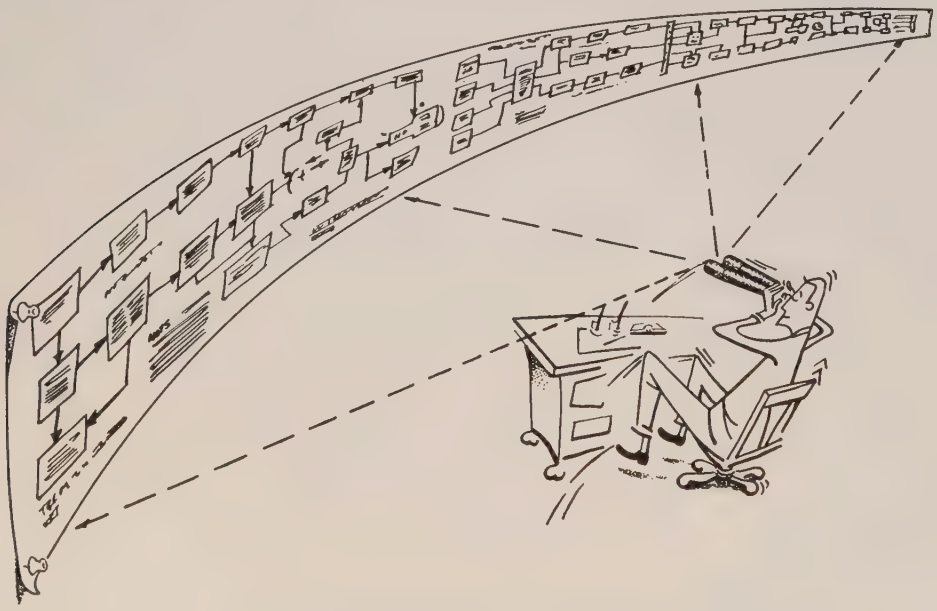
Mere bits of factual information can be communicated quite easily, and are best put down in tabular or graphical form. The significance of the general pattern, however, demands the use of words. For example, the mathematical expression, $1/2\ g_t^2$, expresses an idea that pertains to a falling body. But does this apply to any falling body? Does it apply to airplanes and parachutes? There are circumstances where this expression can be used and others where it is wholly inadequate. The mathematics associated with the expression (tables of values) only apply to freely falling bodies in a vacuum. Words must be used to clarify the limitations and the significance of the symbols.

It is a common misconception by students in engineering that writing is far-removed from the work of an engineer in industry. It is quite the opposite. If there ever was a time when a scientist worked alone in his laboratory isolated from the world around him, that time is no more. The technical man today is involved not only with understanding his own specialized field of activity, but also the general field of business in which he operates. His contact with the business organization may not be physical, but he is connected with them by channels of communications in which writing plays a most important part.

Norbert Wiener, in his *Cybernetics,* has said, "Any organism, . . . is held together . . . by the possession of means for the acquisition, use, retention, and transmission of information. A group of nonsocial animals, temporarily assembled, contains very little group information, even though its members may possess much information as individuals. Properly speaking, the community extends only so far as there extends an effectual transmission of information."

Dr. Weiner has brought out the idea that any organization depends heavily on its communication machinery. This applies especially to technically trained men who must supply management with proposals for research, current designs, investigations of materials and processes, performance reports, progress reports, etc.

The communication between the tech-



Engineering writers must get the overall picture in their work as well as . . .

. . . the little picture

The trained engineer has a tendency to use symbols and equations when conversing or writing which the non-technical businessman finds hard to understand.

nical and the non-technical man presents a bigger problem than there might at first appear to be. It would seem that scientific ideas and concepts could be explained, where necessary, in terms of ordinary language. The engineer, however, uses an entirely different language in his work than the layman. The symbols, graphs, and engineering terms are not directly translatable into ordinary language, but must be illustrated by analogies or comparisons to the very ordinary. In this process a certain amount of the precise meaning and accuracy of the technical term must be sacrificed. Ideas between technical and non-technical personnel can be easily communicated only as long as the explanation remains in general terms. When the attempt is made to investigate a problem in detail, it becomes necessary either to make up new words or to use ordinary words in more limited senses. This leads to misconceptions because the meaning of the word to the writer is not the same meaning gathered by the reader. It is necessary to attempt to speak more exactly than is done in ordinary conversation. This gives rise to a new language of technical terms which are unfamiliar to the non-scientist. They become so familiar to the scientist through everyday usage that it is hard for him to realize that everyone is not acquainted with the words or their meanings.

One mark of a successful engineer is that he can analyze his work and explain it to others whether they are technically trained or not. With men at his own level that he works with every day, this will usually be an oral explanation. It will not be difficult since there is no semantic difficulty. However, it is a different situation when an engineer must present a written report to a non-technical supervisor or executive. The report may be an analysis and solution of a problem or the progress made on a particular project. The report must go into more detail than would be necessary if written to another engineer, but it still must be accurate and unpretentious. Care must be taken not to write below the reader's level of intelligence since this not only wastes valuable time, but is exasperating to the reader and an insult to his abilities.

Much of an engineer's time is spent in writing reports if he is in a supervisory position. Management relies on these reports as an information link between it and engineering activities. Therefore, the report must be timely, accurate, and complete. The form that the report takes is dependent upon several things. Probably the most important is the objective desired by such a report. If it is merely for the recipient's personal information such as a progress report or a performance report, it should be simple and to the point. Other reports, such as investigations of processes or proposals to conduct research should be complete and detailed. The report must also take into account the recipient, his position, his particular field,

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and the authority he has. The circumstances in which the report is presented will also determine its general style. It may be presented along with an oral report or it may be read aloud in a board meeting with its originator present. In either case the report should be complete and follow a natural pattern of thought. The writer may be requested to provide further evidence or asked to clarify a statement, so he should know the subject matter well and have his sources of material ready for reference.

It is evident, then, that the technical report does not have any set format. A company may have report forms, but these are only for routine reports on attendance, quality checks, etc. Generally speaking, the engineer must weigh all the considerations and decide himself how the information is to be presented in the report. Regardless of the form or style, the material should be presented in a way that commands attention and yet does not exaggerate the facts or their significance. If action is desired as a result of the report, it should be suggested or implied in the text.

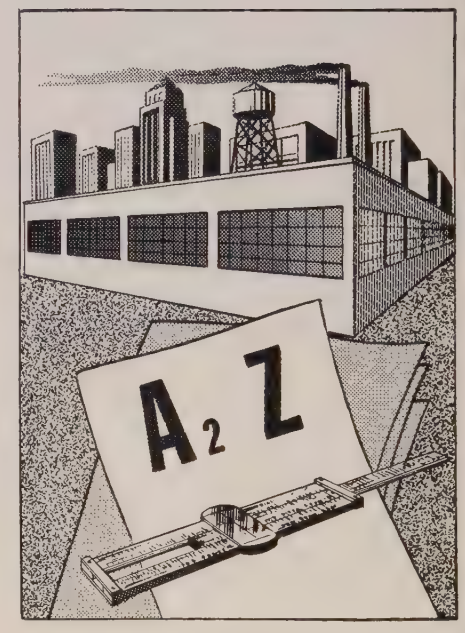
Another phase of technical writing which is sometimes referred to as report writing, is the presentation of technical papers before professional societies (IRE, AIEE, ASME, etc.) These societies are the spokesmen for their particular field of engineering. They have risen chiefly from the desire to correlate the new discoveries and concepts in that field and to communicate this information to other engineers. To this end they publish the proceedings of their meetings for distribution to its members. These publications give their readers a general description of current engineering projects. In addition to the technical papers presented, the proceedings contain listings of new books in the field. The societies also endeavor to set standard symbols and establish explicit definitions of pertinent engineering terms. These appear periodically in their publications.

Before a paper is presented to the professional group, it is reviewed by a board set up by the society. This review board is composed of top ranking engineers in the profession, who serve as annotaters on the papers. Since the material is investigated and criticized so carefully before acceptance for presentation, the proceedings offer an excellent opportunity to observe engineering writing at its near best.

There are also many commercial publications that attract the writing talents of engineers. The magazines range from the smaller-size popular editions to the more erudite scientific journals.

The popular magazines are written to a semi-technical audience and confine themselves to brief, highly illustrated, descriptions of new ideas or new products. The material is found useful to laymen with a somewhat mechanical mind or a flair for gadgetry. "Hams" or experimenters also use the new ideas in the popular editions for incorporation in their own equipment. For the most part these magazines are merely a handyman's guide, but since some of the articles deal with engineering concepts, they can be called technical literature. The magazines usually have quite a wide circulation, so they are used by engineers that desire a lot of publicity on some idea. It is not very difficult to write an article for acceptance in these magazines, as they usually accept any that show a little intellectual thinking and have enough photographs to supplement the text.

Each field of engineering has several good commercial publications. These publications present new ideas and concepts in that particular field. They depend on engineers or scientists in industry to supply the technical articles—either written on their own time or with their company's consent and approval. The articles are usually of a technical nature and are very instructive in explanation of the theory involved.



They are usually concerned with practical problems and practical solutions to them. The publications are read by many engineers who desire to keep up on latest equipment and ideas in their field. Because of this the magazines provide a good opportunity for young engineers to express themselves and present their ideas to other engineers. In many instances a company may want to publicize a new discovery or piece of equipment and will request the engineer concerned to write an article on it for publication. In this event the company will require recognition along with the

author. In general, if any company time has been spent in working on the project or the writing of it, that company should be given credit in a byline or introductory note. An engineer will find that such an article will add to his reputation and prestige in the company and in his profession.

Another form of technical writing is found in the scientific journals, such as *Science* or *Scientific American*. These journals are devoted to pure science rather than the applied science in previously mentioned publications. As such they are primarily written by physicists engaged in experimentation and development in pure research. Most of these men are authorities in their field.

From the standpoint of writing, the scientific periodicals are as well or better prepared than the publications of the professional societies, but the written material and illustrations are geared to a different intellectual level. There is one fact that cannot be overlooked here. The authors of the articles in scientific journals are not burdened with the necessity to write to readers less informed than themselves. This is evident in reading some of the articles in such magazines as the *Scientific American*. The writers do not "pull any punches" in the terms they use and certainly do not try to define the words and phrases contained in their articles. Their main objective is to present their discoveries or products of their research, not to the public, but to other scientists. This allows them to bypass the greatest difficulty of most technical writers, that of writing to men of a different level of technical understanding.

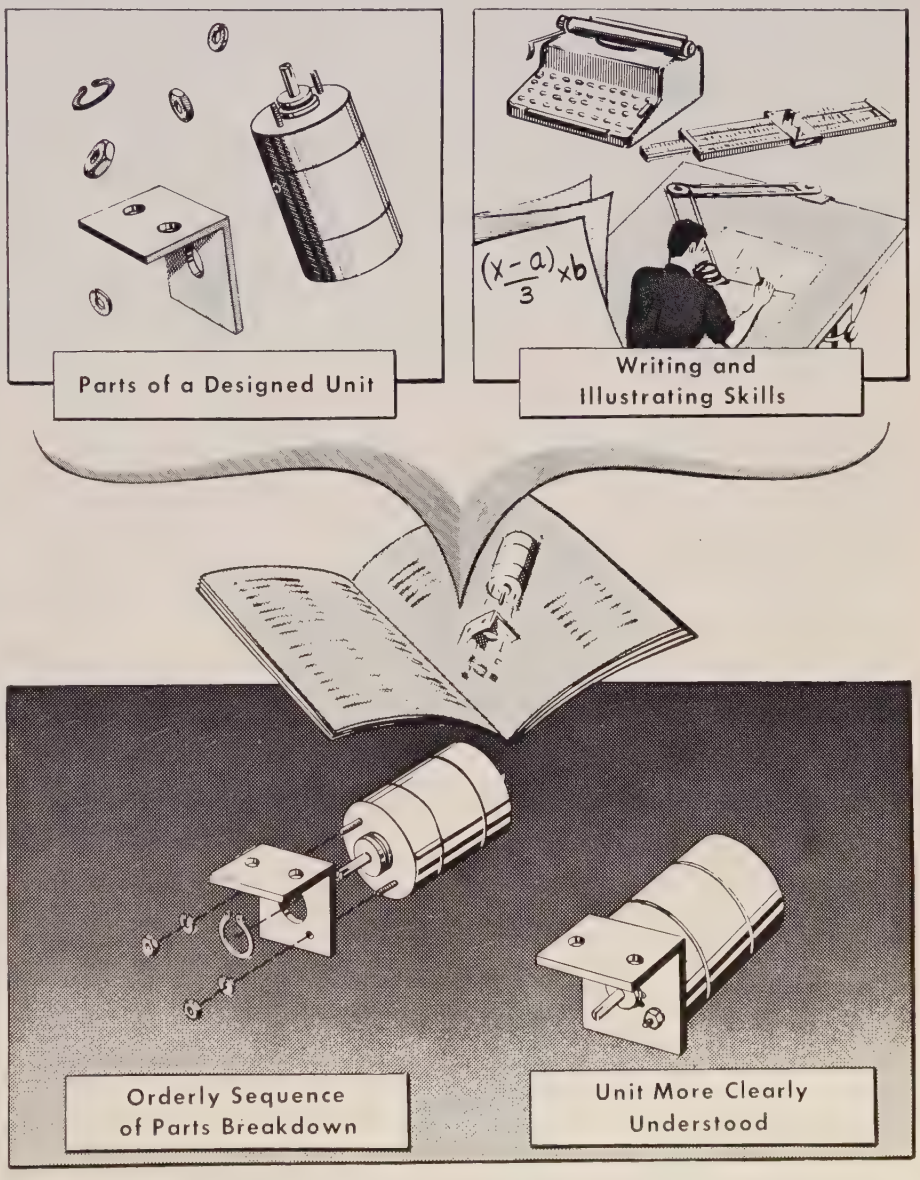
The commercial scientific publications however, do provide a good source of literature on current discoveries and happenings in the scientific world around us.

Engineering writing has risen within the last few years as a separate phase of engineering in itself. It has been greatly accelerated by the demands of the aircraft industry. There are many companies (primarily along the West Coast) that are working under military contract to the Air Force or Navy. They manufacture the airframes, armament, armament fire control systems, radar equipment, or other equipment that goes into our country's jet fighters, interceptors, and bombers. Other companies are engaged in the manufacture of airframes and parts for commercial aircraft. The complex mechanical and electronic equipment that goes into the planes requires many well trained technicians for its support. This is where the *engineering* writers come in. They are employed by the companies to write instruction manuals on the equipment. The men are mostly electronic engineers, physicists and mathematicians with college degrees. The task before them is a challenging one. The writers must know every unit, its components and its function in order to write instruction books for the operation, maintenance, repair, and overhaul of the system to which that unit belongs. They must be able to explain such things as a roll servo or a range gate amplifier to technicians, who, for the most part, know little more than basic electronic theory. The engineering writers must know, in addition to the functions of components in each unit, the broader picture of that unit's purpose in the overall system, and further, that system's function in relation to flight operation or the releasing of the armament. It is not only that the engineering writer must comprehend and understand all the theory connected with it. Otherwise the manual would be little more than a book of facts, rather than a technical instruction manual.

An engineering writer gets a much broader picture of the organization and the products involved. He is in a better position than other engineers to learn more about the company for which he works. Because of this he is valuable to management and usually rises rapidly into executive positions.

The near future holds great promise for engineering writers and engineers in other fields with writing abilities. Due to the increasing emphasis on the decentralized concept of management control, the scientific personnel who can communicate with both the non-technical management and their fellow engineers are becoming increasingly more in demand.

The world lies at the feet of the well-trained engineer. He must be able, however, to communicate, through engineering writing, to others about him so they may make use of the technical knowledge available to them.


Parts of a Designed Unit
Writing and Illustrating Skills
Orderly Sequence of Parts Breakdown
Unit More Clearly Understood

Make-up of the parts-breakdown section of a technical manual.

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. . . in the field of INSTRUMENTATION

Among the many engineering problems relative to designing and developing today's tremendously powerful aircraft engines is the matter of accumulating data — much of it obtained from within the engines themselves — and recording it precisely. Such is the continuing assignment of those at Pratt & Whitney Aircraft who are working in the highly complex field of instrumentation.

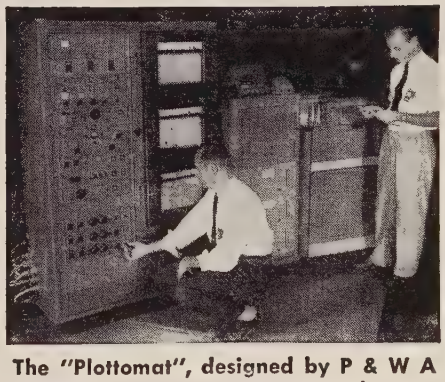
Pressure, temperature, air and fuel flow, vibration — these factors must be accurately measured at many significant points. In some cases, the measuring device employed must be associated with special data-recording equipment capable of converting readings to digital values which can, in turn, be stored on punch cards or magnetic tape for data processing.

Responsible for assembling this wealth of information so vital to the entire engineering team at Pratt & Whitney Aircraft is a special group of electronic, mechanical and aeronautical engineers and physicists. Projects embrace the entire field of instrumentation. Often involved is the need for providing unique measuring devices, transducers, recorders or data-handling equipment. Hot-wire anemometry plays an important role in the drama of instrumentation, as do various types of sonic orifice probes, high temperature strain gages, transistor amplifiers, and miniaturized tape recording equipment.

Instrumentation, of course, is only one part of a broadly diversified engineering program at Pratt & Whitney Aircraft. That program — with other far-reaching activities in the fields of combustion, materials problems, mechanical design and aerodynamics — spells out a gratifying future for many of today's engineering students.

Instrumentation engineer at Pratt & Whitney Aircraft is shown investigating modes of vibration in a blade of a single stage of a jet engine compressor.

Special-purpose probes designed and developed by P & W A engineers for sensing temperature, pressure and air flow direction at critical internal locations.



The "Plottomat", designed by P & W A instrumentation engineers, records pressure, temperature and air flow direction. It is typical of an expanding program in automatic data recording and handling.

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University of Illinois

. . . *past and present*

by Dotty Hazel, Eng. Physics '59

Did you know that the University of Illinois started out as the Illinois Industrial University?—that the "Daily Illini" was once a very learned and heavy magazine called "The Student?"—that fraternities were out-lawed on this campus for nine years? Looking into the past of the University, one finds that it had quite a time getting started; however, once on its feet, the University of Illinois grew rapidly to become what it is today.

To begin with, the ordinance of 1787 gave each state in the Northwest Territory two townships to be "exclusively bestowed upon a college or university." Then, after 1818, one-half percent of the proceeds from the sale of public lands was to be used for education. Neighboring states took advantage of this opportunity—but not Illinois. Illinois seemed to be indifferent to higher education. The two townships were sold at absurdly low prices.

When the Morrill Land Grant bill was passed by Congress and signed by President Lincoln, Illinois had, in a way, made up for her sad neglect of her former opportunities. This act was instigated and fought for by Illinoisians—one in particular, Jonathan Baldwin Turner. The act became known as the Morrill Act. It provided that 30,000 acres of land for each member of Congress to be given to the states. The grant had to be accepted within two years, and was to make up a fund to be "inviolably appropriated" by the state "to the endowment, support, and maintenance" of, at least, one college whose main purpose was to teach agriculture and "Mechanic Arts." This, however, did not exclude the teaching of the classics and science. The legislature of each state had the power to say how what was to be taught.

Illinois accepted the Morrill Land Grant in 1863, but this was only the beginning of the fight for a state university, for some men had "better" ways for dividing the money among other schools than stated in the Act. Finally, by not too honest means, Champaign County was chosen as the site for the new university. In 1867, five trustees were appointed. The board of trustees met for the first time in Springfield and chose John Milton Gregory for president of the new Illinois Industrial University—later changed to the University of Illinois by the state legislature.

The new university's first curriculum contained five departments. They were agriculture, polytechnic, military, chemistry and natural sciences. The latter department caused considerable excitement, for it included most of the curricula of the classical colleges of the day. It was widely opposed and denounced as one of the "old colleges." Wild tales were associated to the discredit of the new university. Things became so bad that

The old seminary building—served as a dormitory as well as classroom building.

Green Street in 1874 as seen from a window in University Hall. In the background are the main building, the Drill Hall, and the Boneyard.

a committee was appointed to visit the institution. The report of the committee did much to allay criticisms and prejudice against the university.

On March 2, 1868, only 50 students enrolled in the university. This enrollment increased to 68, but most of these were from Champaign County. College life was not too exciting in those first years. The students' routine was largely cut out for them by the requirement that all students should work two hours a day at manual labor and that they should attend military drill on two or three afternoons a week. Then with the beginning of the fall term of 1868, the students had to wear uniforms.

Environment was first centered in the old seminary building. It served as a dormitory as well as recitation hall. Nearly all the students were financially very poor, preventing much "extra-curricular" activity. Probably the most prominent activity of student life was student government, which was introduced in 1870. For several years it was a useful bit of machinery. Those who lived under it in its early years had pleasant memories of it, but later students thought it should have been abolished long before it was. Student government was partly used as a drill in parliamentary procedure, but was also meant to enforce good conduct on campus. For a time, it was successful.

About the same time student government was introduced, the University's library boasted 5,000 volumes. The present library building which was started in 1896 houses not only the largest library on the campus of any state institution, but the third largest university library in the world.

Admission to women was granted in the university's third year. The trustees had voted the year before to admit women "as soon as buildings are provided." In 1871, 22 women attended the university.

Also in 1871, the newly formed University band furnished music for commencement as it has done ever since. In November of the same year, the first monthly periodical was published. It was called "The Student"—later changed to "The Illini." It was heavy, learned, and serious, completely unlike college magazines of today. For a while, "The Illini" was published weekly. Then, when daily publication began, the name was again changed—this time to its present name, "The Daily Illini."

For a time, students were not allowed to join fraternities. Starting in 1881, an entering student had to give his pledge not to join a fraternity. Students had to make a similar pledge saying they had not joined a fraternity during their time in school before they could receive their diplomas. Just before this ruling was made, the Kappa Kappa chapter of Sigma Chi had been organized. This pledge was finally omitted in 1890 and Sigma Chi reorganized a year later.

The College of Engineering began to function in 1870. It contained mostly shop work, mechanical drawing, and surveying. These courses, together with math and liberal training subjects, made up the main part of the engineering curricula. Provisions were made for the departments of Mechanical Science and Art, Mining Engineering, Civil Engineering, and Architecture and F.A.A. There was also some physics in the curricula, but it was not made a separate department until 1889. The departments of Santary Engineering and Theoretical and Applied Mechanics were the next ones to be established. Electrical Engineering followed. E. E. was first a part of the Physics Department, but was made separate in 1898. Then came the formation of Railway Engineering Department and Ceramic Engineering. In-

struction in drawing and descriptive geometry was started when the engineering college was first founded, but the General Engineering Drawing department was not started until 1921. Agricultural Engineering was started next, and finally, Aeronautical Engineering.

The Engineering College entrance requirements were rather indefinite until 1899. After this date, the requirements were gradually made stiffer until they became what they are today—15 units of high school work, some of which must be in specified subjects.

In 1909, the University of Illinois Engineering College began the Engineering Experiment Station. This organization was the first of its kind in the country in an educational institution. Most of the credit for the idea and organization of the EES can be given to Prof. L. P. Breckenridge, M. E. head. The purpose of the EES was and is to "conduct investigations and make studies of importance to engineering, manufacturing, railway, mining, and other interests of the State." The EES also does coordinate research programs with other schools and colleges of the university and certain departments of the State. The central office of the EES is in Civil Engineering Hall; however, work is done in several different buildings on campus. Research is carried on whever equipment and facilities are available.

Construction included Lincoln Hall, Bevier Hall, the much added-to Davenport Hall, Altgeld Hall, and the fundshy Auditorium, whose bad acoustics have become a campus tradition. Attempts to rename the Mississippi of the engineering campus, The Boneyard, to Silver Creek, were laughed into oblivion.

Edmund James was president from 1904 to 1920. During his regime, the University flowered on a grand scale with students, faculty members and speakers from all over the academic world. During this time, the present site of the Chicago Professional School on Chicago's West Side, was acquired. Here once stood the ball park of the Chicago Cubs. Enrollment increased to 9,249. The Armory, with an unimpeded space of 200 by 400 feet was built in 1914. Illini Hall was built as a YMCA in 1908. Both were used to house cadets prior to and during World War I.

David Kinley, professor of economics and dean of the Graduate School was named president in 1920. By 1921, Illinois was the third largest university in the nation with an enrollment of over 10,000. Smith Music Hall, McKinley Hospital and Memorial Stadium were erected. Red Grange helped dedicate the Stadium at Homecoming, 1924, with his fabulous victory against Michigan.

During this period, "the flapper age," "the Golden 20's" the coonskin coats, old wrecks of cars, wild snake dances and extensive fraternity and sorority life ruled the campus. With the depression came a change.

Harry Woodburn Chase was president from 1930 to 1933. Under Chase, new student rules and regulations to promote student self-government and social responsibility were formulated.

Arthur Cutts Willard, head of the mechanical engineering department and acting dean of the College of Engineering, was president from 1934 to 1946. The Illini Union, was begun a PWA grant in 1939 and completed in 1941. It stands on the site of University Hall, one of the original buildings on campus. The first Men's Residence Hall was built in 1942. Gregory Hall, housing the School of Journalism and Communications and the School of Education was completed.

George Dinsmore Stoddard became president in 1946. With the war's end the "temporary" branch at Navy Pier in Chicago, and the Galesburg branch were opened to take care of the vast influx of students. The Ice Skating Rink and Stadium halls were used for housing. The Electrical Engineering Building, Betatron, Chemistry East and LAR were built. Galesburg was closed in 1949, but Navy Pier's enrollment grew and with it grew the clamor for a permanent four-year state University in Chicago a clamor which still exists.

Today, the University boasts 20,000 students on the Urbana campus alone. It has come a long way from one seminary building housing 68 students and the faculty. At the present, the university faculty numbers roughly 3,000 instructors and has over 140 buildings. It is the fourth largest university in the country. Illinois has made up for her former neglect of higher education.

A view of the engineering campus before the Mechanical Engineering Building and the Union Building were built.

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Production of . . .

ILLINOIS TECHNOGRAPH

This article, like all other articles in this magazine, was in the first stage of preparation several weeks ago. Since then, it has seen all the different phases of editing by students: composition of the complete magazine from the articles, short items, illustrations and advertisements; printing by the Illini Publishing Co.; and distribution by the business staff, composed entirely of students. In fact, that is what this article is about—its own preparation.

The *Technograph* staff is composed of engineering students who are interested in writing and editing or in the business procedures of publishing and distributing a magazine. For some, these activities are in preparation for a career in one or another form of technical journalism. For others, these activities are an absorbing hobby and the student gains valuable experience by his participation.

The preparation and writing of an article and the development to its final form are the duties of the editorial staff, which is directed by the editor and the associate editor. They and their assistants decide upon the articles and illustrations which will appear in each issue.

After the articles and illustrations for the issue have been chosen, the associate editor makes the assignments to the reporters. Usually one and sometimes two reporters are assigned to a feature or department. They generally have abut four weeks to meet the deadline.

For the initial preparation, the reporter determines the scope of his subject and selects the material that will be covered. He investigates all sources of information. The business of getting first-hand and up-to-date news on the subject is an interesting part of the reporter's work. This includes interviewing, investigation and obtaining contemporary literature on the subject. All this work is preliminary to the actual writing of the article.

While the reporters are gathering information and writing the articles, the make-up editor determines the types of pictures to accomodate the articles and makes the assignments to the staff of photographers. The photographers have the job of getting pictures that are not only technically illustrative, but that also show good photographic composition. Frequently the reporter, on his investigation finds pictures that he considers valuable for illustrating his article and he gets them for the photographers. Certain types of pictures, like commercial products, are obtained directly from their source, and this reporter can do when he gets his preliminary information. The make-up editor must meet the same deadline as the reporters.

After all the copy has been turned into the office by the reporters, the articles are edited. They are reviewed and revised, and necessary changes are made to improve the form and composition and to conform to the particular style used by the magazine. Each assistant editor checks over the material turned in by the reporters under his supervision, and the editor then reviews all the copy. The edited copy is then taken by the editor to the Illini Publishing Co. for processing.

At the same time the copy is being edited in the Technograph office, the make-up editor and the editor are marking up the illustrations for size. These photographs are then taken to G. R. Grubb and Co. to be engraved. The production of a metal engraving suitable for printing the varying tones of a photograph is an interesting process.

The first step in engraving is the production of a "half-tone" negative. The illustration is "shot" through a half-tone screen placed upon the negative. The half-tone screen consists of two plates of glass, each striated by a diamond cutter, placed one upon the other so that the unit is cross-hatched. The striations are very fine grooves which are filled with a black pigment. The half-tone screens used in making plates for this magazine have 120 grooves to the inch, and therefore 120 times 120 squares to the square inch.

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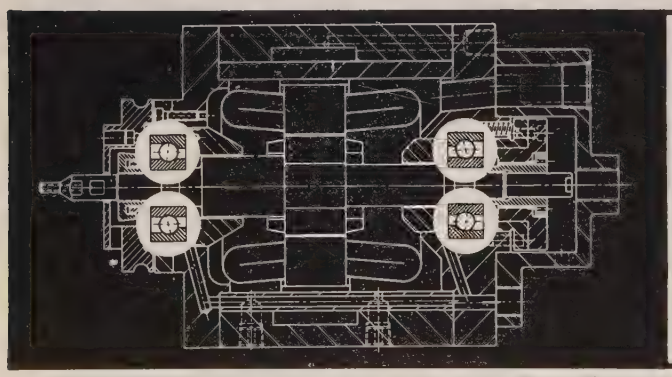

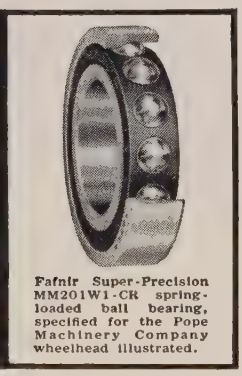

Fafnir Super-Precision MM201W1-CR spring-loaded ball bearing, specified for the Pope Machinery Company wheelhead illustrated.

This Pope-built motorized grinder wheelhead, equipped with its original Fafnir Super-Precision Ball Bearings, has totaled over 14 billion revolutions, operates at 72,000 rpm. Used for grinding the races of extra-precision ball bearings, this wheelhead is still in production-line service.

Fafnir engineers worked with Pope Machinery Company in selecting bearings for this high-speed wheelhead. The specification of Fafnir ball bearings plus their remarkable record of performance, demonstrates how Fafnir keeps pace with machine tool progress . . . and why more and more engineers look to Fafnir for help with bearing problems. The Fafnir Bearing Company, New Britain, Conn. (23 Branch Offices)

The Fafnir Bearing Company consists of six plants — all located in or near New Britain, Connecticut. Manufacturing space (including a new instrument bearing division) totals more than 1,250,000 square feet.

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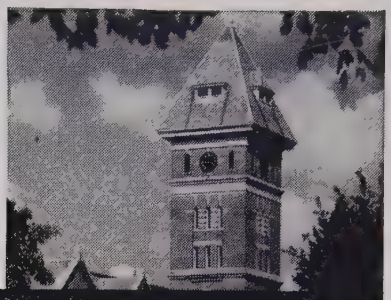

PURDUE

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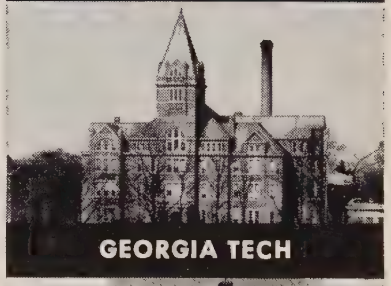

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When the light from the picture passes through this screen to the negative in the camera, the light is refracted so that the square is reduced in size on the negative. These squares on the negative are larger for greater intensity of light, which corresponds to a lighter tone of gray. The resultant negative of minute squares is called a half-tone negative.

The half-tone negative is next printed onto a metal plate covered with photo-sensitive enamel. This plate is developed and a half-tone print of enamel is left on the metal. The plate is now etched, so the parts not coated with enamel become the depresed portion of the engraved plate or "cut." The metal plate from which the cut is made is usually a zinc or copper plate and brass is sometimes used to produce a tough plate. Copper is etched with hydrochloric acid, zinc is etched with perchloride of iron and brass is usually electrically etched. From G. R. Grubb's finishing department, the cuts go to the Illini Publishing Co.

The Illini Publishing Co. is a non-profit organization which was established in 1911 to print and distribute the *Daily Illini* and other student publications of the University of Illinois, and to do a general printing and publication business. All proceeds from the business of this non-profit organization go back into the reserves of the company and are used to further improve the publications. The company is subject to the general authority of the president of the University and the faculty-student board of control. The *Illinois Technograph, The Daily Illini* and the *Illio* are all published by the Illini Publishing Co.

At this point, the edited copy is ready to be marked up in the printing shop of the publishing company. In the margins of the copy are marked the type face, size of type and measure of the width of the column to guide the setting of the copy by the operator of the linotype machine. These line casting machines are Intertypes.

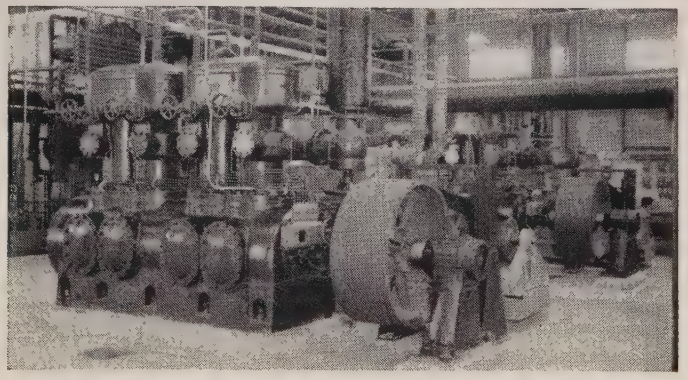
There are two main steps in the composition or setting of copy. The first is the line casting on the Intertype. When the operator presses a key on the keyboard of the Intertype, a mold for casting a letter, called a matrix or "mat," is released and drops into line. The type metal, which is a mixture of zinc, lead tin, copper and antimony, is kept in a molton state ready to be cast into a line of type or slug. When a line of mats is ready for the casting of the slug, the molton type metal is forced against the mats and into the depressed letters in the face of the mats. When it cools, a line of type, or slug, is ejected from the machine. The second step in setting copy is the assembling of the slugs into columns of type. Such a column of type is called a galley.

Proofs must now be pulled from the galleys on a proof press. To do this, the galley of type is placed on the proof press, the type is inked, the paper placed directly on the type, and a roller moved over the paper. Two proofs of each galley are pulled and sent to the *Technograph* office for the correction and for making up the magazine dummy.

One copy of each galley proof is checked and corrected, first by a member of the editorial staff, then by an assistant editor and then by the editor. This proof reading requires approximately three days after which the proofs are sent back to the typesetter for correction. At the same time, the other set of galley proofs is being used to make up the magazine dummy. The dummy is a rough assembly of the entire magazine, formed by cutting parts from the galley proofs and pasting them along with illustrations and headlines on the pages of an old magazine. This work, which requires approximately a week, is done by the make-up editor, asisted by the editor.

The completed dummy is then turned over to the printer for make-up of the pages of type. After the typesetter has corrected the galleys, and the headlines have been set either on a Ludlow line casting machine or by hand, the printer assembles the body type, headlines and cuts into page forms, according to the pages of the magazine dummy. In the print shop this operation is called make-up. One proof of each page is then pulled and returned to the Tech office for correction. These proofs are checked and corrected first by the editorial staff and then by the editor assisted by the make-up editor and are then returned to the printer. In the print shop, corrections are made on the page by substitution and by resetting type. The pages are then locked up in forms, or chases of eight pages each, constituting what is known as a printing signature. There are 88 pages in this magazine, and 11 printing signatures of eight pages each are used on the printing press. The pages are arranged in these printing signatures so that when the paper is printed and folded, the pages will be in the order they are to appear in the finished magazine.

The Illini Publishing Co. uses a flat-bed cylinder press. The printing signatures are locked on the bed of the press, and the press makes the printed impression by rolling the paper, held to a cylinder by grippers between the cylinder and the signature chase, over the type. The type is inked by a roller prior to each contact with the paper. A sheet of paper, printed on both sides and containing 16 printed pages, is called a



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If you are a **PHYSICIST** or **MATHEMATICIAN** you may be involved in such fields of theoretical and experimental physics as weapons design, nuclear rockets, nuclear emulsions, scientific photography (including work in the new field of shock hydro-dynamics), reaction history, nuclear physics, critical assembly, high current linear accelerator research, and the controlled release of thermo-nuclear energy.

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binding signature. Before being bound, these binding signatures are placed on trays to dry because the ink used is job ink which must dry by oxidation.

When the pages have dried for about 24 hours, the binding process begins. The signatures are fed into a Dexter folding machine. This machine can be rigged-up with tapes for a variety of page sizes and folds, and for the 16 page binding signature of this magazine, it is set to fold the paper three times. Then all groups of pages are assembled into the proper sequence by page number and the cover is wrapped around the signatures. The assembled magazine is then stapled together with a saddle stitch, and the magazines are then trimmed with a power cutter.

Sixty magazines are trimmed simultaneously on the power cutter. As a safety measure, the operator of the power cutter must manipulate two releases at the same time, one on each side of the machine, in order to allow the blade to descend. The magazine is usually trimmed to 8½ by 11⅝ inches, but the trim size is often altered slightly to "bleed" an advertisement on the cover. A bleed ad has a picture that extends all the way to the edge of the cover, consequently the magazine must be trimmed properly to bleed the advertisement. After the magazines are trimmed, they are ready to be distributed by the circulation department.

The life span of a publication would be snapped short if it were not distributed promptly to its readers. This is why every publication organization which hopes to have more than one issue must have a circulation manager. It is his job to see that all of the magazines are mailed and distributed to the proper persons and that the subscription sales are carried through down to his last ounce of energy.

The third problem about which the circulation manager perspires freely is the subscription sales. The actual selling of the subscriptions is carried on by the entire staff during the cvampaigns which usually take place at the beginning of the fall semester. The subscriptions are sold on a whole year basis. In order to boost the efficiency of the campaign, booths are placed in the engineering buildings and the sales made from there. A periodical is very dependent on its circulation. It is not the money that it receives from a large number of sales that keeps a magazine aloft, but the advertisements that it can obtain because of a large circulation.

The advertisements carried in *Technograph* by large firms is handled by the business manager. All these advertisesment are obtained for the *Technograph* and other engineering college magazines Littel-Murray-Barnhill, Inc.

The first notice that *Technograph* receives of a company's desire to advertise is a contact from Littel-Murray-Barnhill, Inc. It is stated on the contract who is buying the advertisement, the price and size and the issues the ad is to be run in the magazine. The contract, however is not an order for the advertisement and the firm cannot be held to the contract. The actual authorization to run the ad is the insertion order. The order shows the purchaser, what issue it shall appear in, the priceand size, and an identification of the cut. The last thing to appear is the ad itself.

A record is kept with a list of all the firms which have contracts to advertise in the *Technograph*. Each month this list is checked with the insertion orders, and the cuts to make sure that all of them arein our hands. If anything is missing, a letter is sent to Littel-Murray-Barnhill to find out what happened.

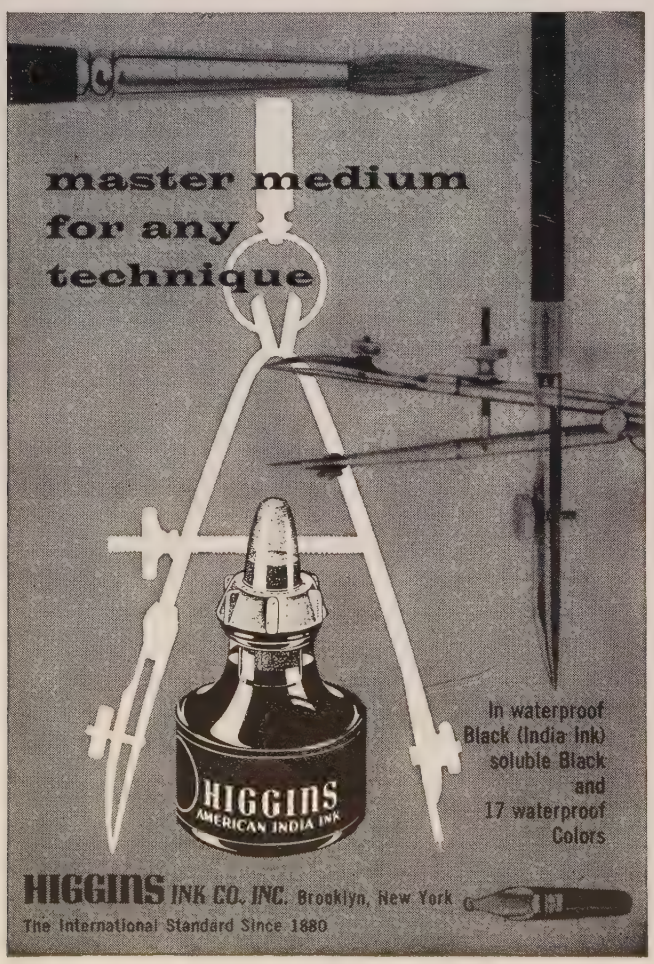
At a scheduled time, the staff gathers up all the cuts and carries them to the printers. The staff then pulls two proofs of each advertising cut. One set is used in the dummy and the other set is checked out for errors. These proofs are returned to the printer at the same time the galley proofs go back.

The business manager must make a report including who advertises in the magazine, and the size and price of the advertisement. This report has to be turned over to the Illini Publishing Co. along with a magazine which has the prices marked on each side of the advertisements. A list of the advertisers must also be supplied to the circulation manager so he can send a magazine to each of the firms.

Without advertising, a periodical cannot be published. Without circulation there will be no advertising. Without publicity there is no circulation. These three statements all add up to prove that publicity is a very important factor.

The publicity for *Technograph* is handled by the circulation manager. Writeups for the magazine, for the staff meetings, and for other publicity are carried in *The Daily Illini*, the *News Gazette*, and the *Champaign-Urbana Courier*. The publicity comes from posters on the bulletin boards and the *Technograph* blotters. However there are plans for widening this department considerably.

The laurels of this magazine rest on two men-the editor and the business manager. It is their duty to see to it that the above operations are carried out and coordinated and only through cooperation of the entire student body will this magazine be able to keep up its great progress.



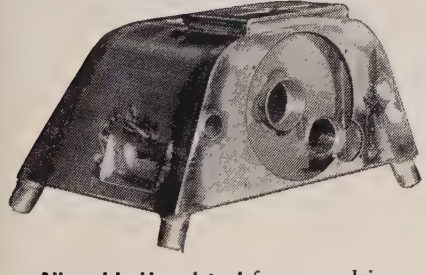
A LOOK AT FUTURE DESIGN

How to prepare for it

NEEDS for even more efficient machinery are daily presenting new demands on the ingenuity of machine designers. In the same way, products themselves must incorporate even greater economies in materials and in manufacture to help keep pace with the pressures of growing competition. This trend in design thinking, therefore, poses a promising challenge to the student engineer.

Rapid strides in the use of welded steel construction point the way to a brilliant opportunity to pioneer new concepts in the field of product design engineering. Fundamentally, steel itself is the most economical material for many products, based on steel's inherently high strength, rigidity and low cost. The challenge, of course, is how to utilize the steel to its maximum advantage.

Here welding holds the answer to new savings in cost of manufacture. New welding electrodes, new welding techniques being introduced almost daily offer new avenues to obsolete production methods of long standing. Typical savings through the use of welded steel are shown in the following example.



All-welded headstock for power drive is made from 16 gauge sheet. Estimated to be 20% more rigid, weigh 28% less, cost 44% less than cast iron design. Photo courtesy Oster Manufacturing Company, Cleveland, Ohio.

It is to your advantage to keep pace with the progress of welding techniques. You can start with helpful manuals and bulletins available to you by writing . . .

THE LINCOLN ELECTRIC COMPANY
Dept. 6200, Cleveland 17, Ohio
The World's Largest Manufacturer of Arc Welding Equipment

Chicago's Transit Answer

by Harry Hirsch, E. E. '57

A preceding article dealt with the problems of mass high-speed transportation and the potentialities of the monorail concept in helping solve these problems. While the monorail is still in experimental stages, other means of high-speed transit are highly developed. In Chicago, we see both the experimental and established methods employed to help move people faster. Its more conventional answer to the transit problem is supplied by Chicago Transit Authority's use of elevated and subway routes for high speed service, with local and express feeder bus service and outlying parking lots. A new chapter in the story will be written next year when CTA rapid transit trains begin operation in a median strip in Chicago's Congress expressway. Before trains can operate, however, tracks must be laid, stations built and of course cars be available. To solve this last problem, that of equipment, CTA has converted most of its modern "Green Hornet" type rapid transit cars into experimental high-speed cars. Let us examine these two steps.

Shortly after World War II, Chicago Transit Authority and its predecessor, Chicago Surface Lines, began a wide-scale modernization project. During this time, 683 modern PCC-type streetcars

The first part of Chicago Transit Authority's postwar modernization program consisted of the purchase of 683 of these Green Hornet, high speed, all-electric street cars. Due to the city's congestion, the bulk of these cars have been converted to light-weight rapid transit cars operating on Chicago's elevated and subway lines. (Photos by CTA)

Behind the Ships that Set the Pace...
a Master's Touch in Oil

Every Atlantic Blue Ribbon Winner since 1910—from the Mauretania to the swift, sleek S. S. United States . . .

The world's fastest propeller-driven boat, Slo-Mo-Shun IV, skimming water at 178 mph . . .

Maiden voyage of the world's first atomic-powered submarine . . .

Two-fifths of the world's freighters . . .

The race horses and the work horses of the seas—all have one thing in common—SOCONY MOBIL'S *master touch* in lubrication.

Good reason! When the chips are down—when records are at stake—when schedules must be met—the men who know marine machinery look to SOCONY MOBIL for its protection.

★ ★ ★

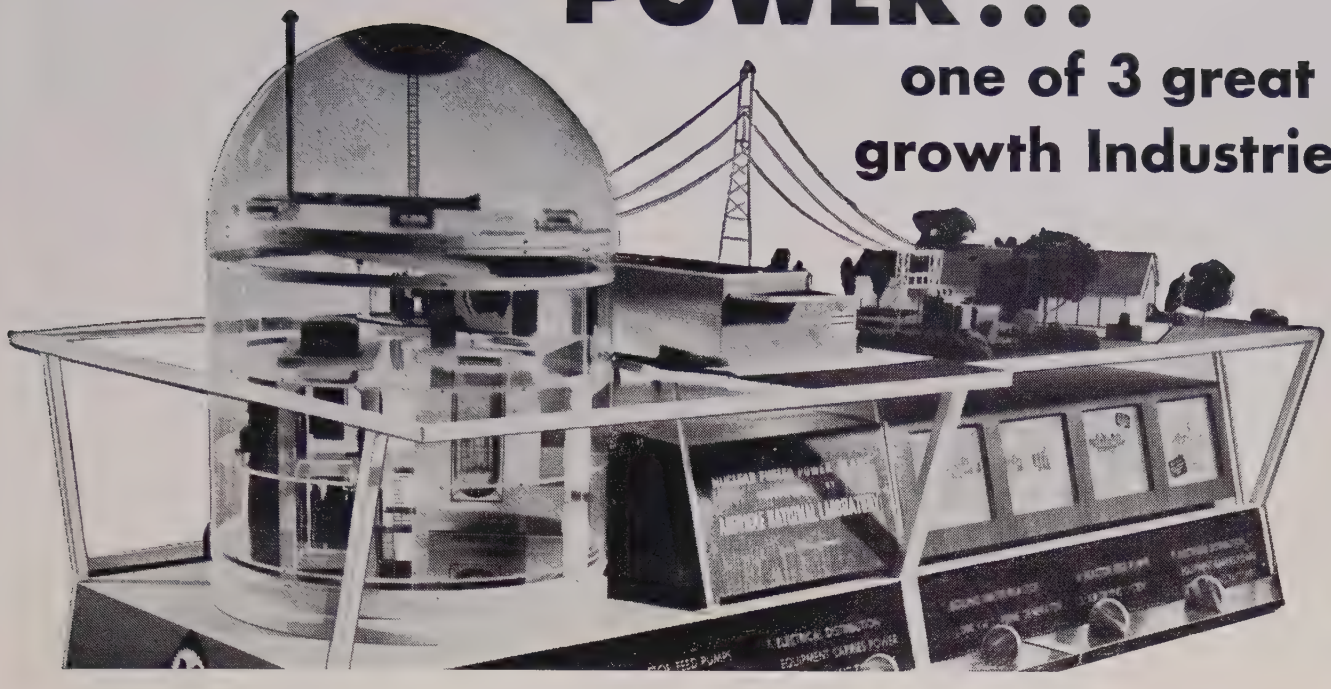
Wherever there's progress in motion—in your car, your factory, your farm or your home—*you, too, can look to the leader for lubrication.*

SOCONY MOBIL OIL COMPANY, INC.

LEADER IN LUBRICATION FOR NEARLY A CENTURY

Affiliates: General Petroleum Corporation, Magnolia Petroleum Company
Mobil Overseas Oil Company and Mobil Producing Company

POWER...
one of 3 great growth Industries



ATOMIC POWER—Allis-Chalmers model of Argonne National Laboratory's experimental boiling water reactor power plant. Allis-Chalmers is supplying specialized equipment for the power cycle: generation, heat transfer, transmission, controls.

GO with the company that's strong in all three!

Hitch your future in engineering to the growth of the U. S. A.—and to a company that supplies the basic needs of growth!

This nation is growing at the rate of 50,000 people every *week!* To supply the needs of these people:

Electric power generation will double by 1965.

A multi-billion dollar program of new highway construction is planned within the next ten years.

Manufacturing output will have to increase by $3.5 billion by this time next year.

And Allis-Chalmers builds major equipment for all of these growth industries! Some examples are pictured here.

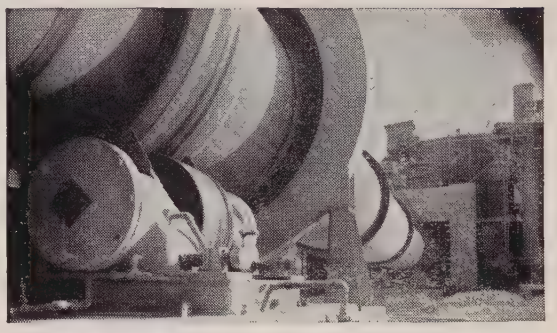
Here's what Allis-Chalmers offers to Young Engineers:

A graduate training course that has been a model for industry since 1904. You have access to many fields of engineering: electric power, hydraulics, atomic energy, ore processing.

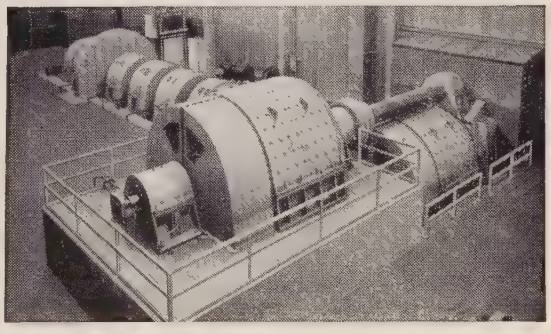
There are many *kinds* of work to try: design engineering, application, research, manufacturing, sales. Over 90 training stations are available, with expert guidance when you want it. Your future is as big as your ability can make it.

Or, if you have decided your field of interest and are well qualified, opportunities exist for direct assignments on our engineering staff.

In any case—learn more about Allis-Chalmers. Ask the A-C manager in your territory, or write direct to Allis-Chalmers, Graduate Training Section, Milwaukee 1, Wisconsin.



CONSTRUCTION demands the vast tonnages of cement produced with Allis-Chalmers rotary kilns and other processing machinery.



MANUFACTURING depends upon the reliable power of electric motors—like these 5000 hp Allis-Chalmers giants powering a rolling mill.

ALLIS-CHALMERS

A-C ALLIS CHALMERS 4977

A train of light-weight rapid transit cars such as these were converted by CTA, GE and Westinghouse into high speed cars and reached a speed 80 mph in comparison to a former top speed of 49 mph.

called "Green Hornets" were purchased as well as over 2,000 buses. The elevated and subway lines of CTA had approximately 1,600 cars of which 450 were all-steel cars and 1,150 were of composite wood and steel construction, some dating back to before the turn of the century. In 1950, CTA purchased 200 modern light-weight rapid transit cars for modernization of some of its lines and called them class 6000.

With the completion of the Milwaukee Avenue subway and the construction of the Congress expressway with a median strip for rapid transit operation, CTA saw the need for more modern equipment. About this same time, the "Green Hornets" were seen to be operating below their maximum potential due to heavy traffic which slowed them considerably. Although buses are slower, they possess greater maneuverability than the trolley and a program of complete substitution of buses for street cars was begun.

CTA then had the problem of how to dispose of its comparatively new street cars economically and obtain more rapid transit cars. Studies showed great similarities between the street cars and rapid transit cars in motors, wheels, braking systems and perhaps body design. It was thought the streetcar body could be easily rebuilt into that needed for rapid transit operation. Experiments proved costs of work and materials would rule this out and in the long run would make the construction of an entire new body more economical. A total of 270 cars have been converted by St. Louis Car Co., builders of the initial 200 cars of the 6000 class, into rapid transit cars.

In this conversion process, the trucks were removed from the street car, after having been thouroughly overhauled and repaired. After modification for rapid transit operation they were installed under the new car body, the old one having been scrapped except for a small amount of interior finish which is removed. Traction motors and the motor generator set, with its control, after slight change were installed in the new car. Electrically operated brakes for use on street car rails were modified for use on rapid transit tracks and the new car was finished. In exterior appearance these converted cars are almost identical to the inital set of 6000 class cars built initially for rapid transit operation. Their interior vital parts however, are from the original street cars which thanks to the ingenuity of CTA and St. Louis Car Co. engineers will run many more miles before scrapping. At this time, CTA operates 470 light-weight rapid transit cars. Eighty additional cars are being reconverted with 50 to follow. Once the Congress expressway is completed, these cars will race from Chicago's west subhurbs along a median strip to a point one mile west of its Loop business district, dive into a subway which connects with the existing Milwaukee Avenue subway leading to Chicago's northwest Logan Square district, all this distance to be traversed with no auto or pedestrian grade crossings. Costs for operation along the expressway will be low since median strip transit operation adds only $250,000 per mile to overall cost as compared to 12 million per mile for a subway, 5 million for an elevated and $500,000 for a monorail.

The second part of the CTA story concerns its experiments with higher speed cars for rapid transit operation. The 470 light-weight cars built by the St. Louis Car Co. have a maximum operating speed of slightly less than 50 miles per hour. Their straight-line acceleration is approximately 3 miles per hour per second up to a speed of approximately 15 mph. At this point, the acceleration rate decreases and the cars reach 40 mph after 40 seconds. In order to compete with expressway auto traffic,

Relics such as these pictured above still run on CTA routes, but are soon to be replaced by the new type rapid transit cars operating in median strip routes along Chicago's expressways.

CTA officials felt that its rapid transit cars should have higher operating characteristics than were found in its cars. In order to determine what operating characteristics could be built into a car, four were set aside for test purposes. Engineers from Westinghouse and General Electric were contacted and agreed to provide their proposed motors and controls, CTA to would provide the car bodies and trucks and install equipment furnished by the other companies.

The problem of the Westinghouse and GE engineers was to build cars that would trim seconds per mile and minutes per run from schedules. The electrical equipment had to be especially designed to provide higher running speeds and faster schedule speeds in the comparatively frequent stop service of CTA. Schedule speed depends mostly on free running speed and rates of acceleration and braking, taking into account passenger comfort and rail conditions. The free running factor is rarely obtained with the frequent stops of CTA and thus would contribute little to schedule time.

This left only the rates of acceleration and deceleration to be available for experimentation. Yet CTA acceleration rates are considered near maximum and increases would add to passenger discomfort and cause possible rail damage and strain. The problem faced was providing better acceleration without increasing rate of acceleration. To do this CTA maximum acceleration rate would have to be maintained beyond 15 mph. The new cars have been equipped to accelerate up to 60 mph in 38 seconds as compared to 40 mph in 40 seconds in the regular light weights of the 6000 class. Given a top speed of at least 70 mph. the new cars would accelerate and decelerate about 3.5 miles per hour per second up to 30 mph instead of up to only 15 mph.

The four 55 hp motors were replaced by four 100 hp motors of approximately half their weight. Moreover, these 100 hp motors have the capacity to produce more than 100 hp during short periods of acceleration, enabling the cars to get to top speed faster. Motors were of a new design in series parallel instead of straight series as on other rapid transit cars. Traction motor control is arranged so that series connection of the motors enables the cars to be operated in train with slower cars of the same type, higher speed being obtained by placing motor circuits in series parallel.

The trucks of the cars before being "souped-up" were felt to be unsuitable for higher-speed operation and were replaced by heavier trucks with larger diameter axles. Wheels 26 inches in diameter were replaced by wheels with a 28 inch diameter.

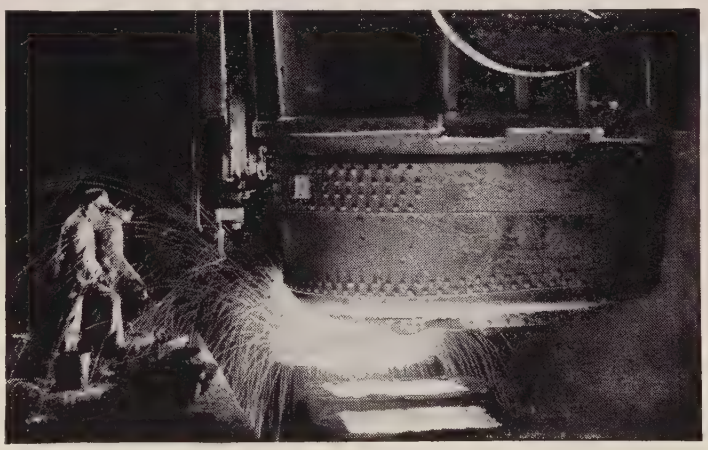
Upon completion of the conversion the cars were taken through exhaustive tests to see what they could do under operating conditions. The cars were found to have a maximum speed of approximately 80 mph in comparison to 49 mph of the 6000 class. Straight line accleration was increased from up to 15 mph. to 30 mph. Speed after 40 seconds was increased from 40 mph to 60 mph. Time of operation between stations one mile apart dropped from 100 seconds to 80 seconds with maximum speed obtained in the next above mile jumping from 47 to 67 mph. One of the tests showed that with stations approximately .5 mile apart, one minute could be saved within a 2 mile distance, or 15 seconds from station to station.

Thus CTA officials have found that a high-speed, high-performance lightweight rapid transit car is feasible, and that fleets of such cars under proper operating conditions can very materially step up the speed of rapid transit service. With the start CTA has made in better rapid transit, many cities can well afford to look to Chicago's answer to transit problems.

INDUSTRIES THAT MAKE AMERICA GREAT

STEEL...

WHEREVER YOU TURN



Abundant, durable, versatile and comparatively cheap, steel in its many carbon, alloy and stainless forms is the most useful of all the metals at man's disposal. Unknown in nature, steel had to be created by man's ingenuity, from iron ore and other available natural materials.

Today, an estimated 1½ billion tons of steel are in use in this country. With a capacity of about 125 million net tons a year, American steel mills can produce close to half the world's annual total. Used for everything from buildings to pins, the total applications of steel are almost countless; *it is virtually impossible to find a product that does not depend on steel for its production or distribution, or both.*

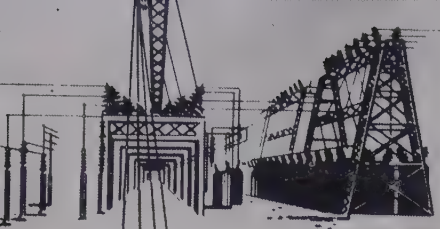
Steel's steady growth reflects the importance of its contributions to America's greatness. Much credit must go to the industry itself, which did not hesitate to execute a bold post-war capacity expansion program of more than 28 million net tons at a cost of nearly 6 billion dollars. The steel companies are carrying on an intensive two-fold program to develop new sources of ore. While spending hundreds of millions of dollars to open fields in Labrador and elsewhere, they are also investing heavily in engineering developments that will make it possible to use domestic low-grade ores such as taconite.

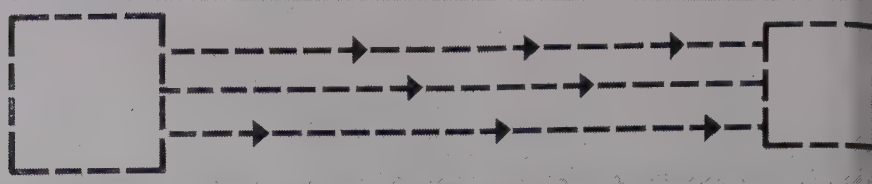
Interwoven with the history and progress of steel is the development of steam generation for power, processing and heat. B&W, through the applications of steam, has long been a partner in the vital steel industry—has brought to it boiler building experience covering almost a century, built on the results of a continuing, intensive program of research and engineering development. In steel as in all industry, improvements in steam generation will continue to make genuine contributions toward still better products and services. The Babcock & Wilcox Company, Boiler Division, 161 East 42nd St., New York 17, N. Y.

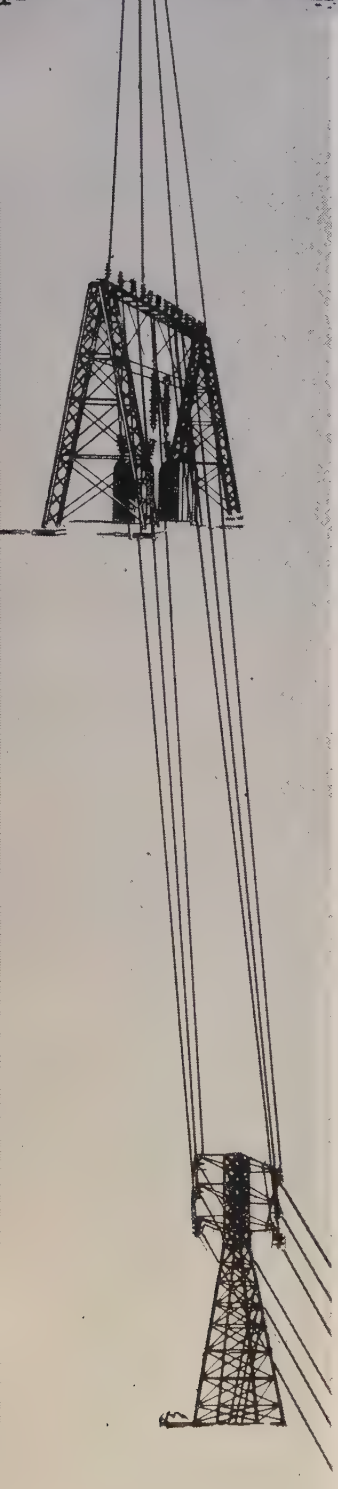
N-201

BABCOCK & WILCOX

BOILER DIVISION







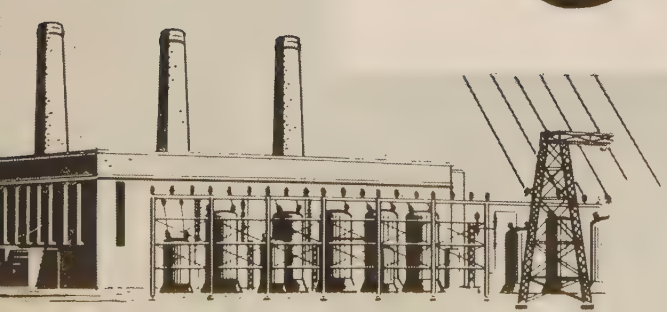
The importance of insulations fo

THE PURPOSE of electrical insulation is to offer resistance to the flow of electricity and thus to confine electrical potential to the conductor material throughout its length. An ideal insulating material would have infinite insulation resistance and voltage breakdown, a specific inductive capacity of 1 and zero power factor. In addition it would be flexible, physically strong and unaffected by abrading, cutting and impact forces, oxygen, ozone, acids, alkalies and water throughout a temperature range from minus 80 C. to the maximum operating temperature of copper. A conductor insulated with a thin wall of such a material would occupy minimum space and would operate indefinitely even at high voltages in the presence of any or all of the above destructive materials with no energy loss within the insulation. All available insulating materails fail to comply with the above ideal in practically every respect.

Insulations for use on electrical wires and cables which are subject to bending during manufacture, installation or use must have adequate flexibility. Flexible insulations for such uses are of two general classes, depending chiefly on the extent that they absorb or are affected by moisture. In one group are included the homogeneous rubber and rubber-like insulations, made from natural rubber or the synthetic rubbers, GR-S, butyl and silicone and thermoplastic insulations such as polyvinyl chloride compounds and polyethylene. Most of these are highly resistant to moisture. The other group consists of insulations built up of one or more layers of fibrous materials such as asbestos, cotton, varnished cambric, various synthetic fibers and paper. Even though these fibrous materials are impregnated with moisture-proofing materials such as paraffin, asphalts and oils, they readily absorb sufficient moisture in wet locations to completely lose their insulating properties. Such insulations must therefore be protected by a moisture-proof sheath such as lead when used in moist locations.

The insulations made from materials appearing in the first group fall into two general classes depending on whether or not they are vulcanized after application to the conductor, namely, (1) thermosetting insulations, those which are vulcanized and, (2) thermoplastic, those that are not vulcanized. Thermosetting insulations are those made from natural rubber, GR-S, butyl and silicone synthetic rubbers. Such insulations are applied to the conductor in a soft plastic condition and attain their ultimate physical properties as a result of a heat treatment (vulcanization) during which the sulfur or vulcanizing agents combine with the rubber. Thermoplastic insulations become plastic enough for application to the conductor simply by raising their temperature. They acquire their toughness again on cooling. From this it follows that thermosetting insulations are less subject to softening at elevated temperatures than

United States Rubber



Another page for **YOUR STEEL NOTEBOOK**

The rifle barrel steel that makes hunting more fun

A .30/06 rifle can get heavier toward nightfall! That's why a prominent gunsmith never gave up looking for a new steel—one that would be lighter, would machine readily, and yet would take the enormous firing stresses of even heavier calibers.

Steels normally used for lightweight barrels gave all kinds of trouble to the gunsmith: distortion, poor finish, high tool costs, trouble with drilling, reaming, rifling. They took this problem to Timken Company metallurgists—and got the perfect solution.

This TIMKEN® rifle barrel steel is free from internal stresses

Developed by the Timken Company, this new steel (center barrel, in picture) made possible a rifle barrel 6″ shorter, 2 lbs. lighter than the previous barrel of the same caliber (left). It withstands the wear of thousands of rounds of firing. Machines to highest accuracy—and to high finish beauty. Machines without distortion. Drills, reams and rifles perfectly. Proof tests to 70,000 lbs. per sq. inch for safety in a .30/06. Has handled overloads up to 100,000 lbs. per sq. inch. Timken Company metallurgists are leading specialists in fine alloy steels . . . as this remarkable new steel will testify.

Want to learn more about steel or job opportunities?

Some of the engineering problems you'll face after graduation will involve steel. "The Story of Timken Alloy Steel Quality" will help you learn more about steel. And you might be interested, too, in the excellent job opportunities described in "Career Opportunities at the Timken Company". Drop us a card, ask for one or both booklets. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN *Fine Alloy* STEEL

TRADE-MARK REG U S. PAT OFF

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

The Development of the . . .

TRANSISTOR TUBE

by Roger L. Harrison, E. E. '59

Few books have been written about the transistor due to its recent discovery, and most of the books that have been written are too technical for the average reader. This paper has been written primarily for those people without technical training in the field of electronics. It is an introduction to the manufacturing process and the uses of the transistor.

The rectifying action of germanium, a semiconductor, was noted as early as 1915. After 1915, but prior to the discovery of the transistor in 1946, the essential theories involving semiconductors were developed. In 1942, experimental work with the high-back-voltage rectifying action of semiconductors began at the Bell Telephone Laboratories. The experiments were headed by John Bardeen and A. E. Brittain. By 1946, they had developed the essentials of the transfer resistor. In 1948, patents were filed, and formal announcements of the discovery were made to the public.

Collector current and voltage characteristics of Minneapolis-Honeywell experimental 60-watt power transistors are checked in company's test labs. (Photos by Minneapolis-Honeywell Co.)

The theories involved in the explanation of the actions of a current through a semiconductor are too technical to be understood by anyone not possessing a good background in physics and chemistry. However, for those people who wish to delve into these theories, I would like to recommend a book written by William Shockley, "Electrons and Holes in Semiconductors."

Germanium is used almost exclusively in the manufacture of transistors at the present time. Germanium is a grey metalloid whose crystals will allow current to pass through in one direction but not in the other. This rectifying power is superior to that of other semiconductor crystals. Several more advantages of germanium over other semiconductors are: its ease of manufacture, its long life, and its excellent current and power gains.

Germanium metal is too reactive to exist in its native state. Germanium oxide, one of its compounds, is obtained chiefly from British coal and as a by-product from the manufacture of zinc. This oxide is heated in a hydrogen atmosphere to form metallic germanium and water. The water boils off leaving the germanium as a fine dust. The powder is melted and cast into ingots about one foot long and one-half inch in diameter.

Any impurities in the ingot, such as nickel, copper, iron, and silicon, are removed in the zone melting process. The bar is placed in an open container of approximately identical shape, and the container and bar together are put inside a sealed glass tube in which is circulated a non-reactive gas. A small section of the bar is melted with an induction coil, and the coil is slowly moved down the length of the bar. Since the impurities in the bar prefer the liquid state, they move with the melted region and collect at one end of the bar. Several passes with the coil are required to obtain the desired purity. The end containing the impurities is cut off, leaving a bar of germanium whose purity is better than 99.9999%.

Whenever a metal cools, it forms many tiny crystals within itself. A single crystal is desable for use in a transistor. Mono-crystalline germanium is produced in the crystal pulling process. This proc

ess, like the zone melting process, is carried on in a nonreactive gas. A purified ingot of germanium is melted in a crucible. Small amounts of another element are added at this point to produce a crystal of the desired resistivity. (Pure germanium has a resistivity of about 65 ohm-centimeters.) The impurity added will determine the type of germanium produced. The P-type has an excess of electrons; the N-type has a deficiency of electrons. A small crystal or "weed" of pure germanium metal is dipped just below the surface of the melt, held there for a few seconds, then slowly withdrawn and rotated. A small amount of vibration may be used, as it helps to completely mix the impurities and to produce a uniformly grown crystal. If the crystals being grown is to be used in point-contact transistors, it is ready to be cut up. However, if the crystal being grown is to be used in junction transistors, one more step is necessory. The crystal is redipped in molten germanium of the opposite type, and a second crystal is fused onto the first. This fused "junction" of two opposite types of germanium is the major difference between the point-contact and the junction transistor.

The basis of the point-contact transisto ris a small, single crystal of either type of germanium. The large, "grown" crystal is sliced with a diamond saw into wafers two one-hundredths of an inch thick. The wafers, in turn, are diced into small squares four one-hundredths of an inch on a side by vertical blades vibrating at supersonic speeds. After the cutting is completed, the squares are cleaned with acid and polished to a mirror finish. The double-grown crystal is cut into small oblong blocks having one type of germanium on each end and separated in the middle by a thin strip of the other type.

Each polished square is the basic component of a point-contact transistor. The other elements of a point-contact transistor are: a nickel tab, three wires set in a glass button, a plastic case, and two "cat" whiskers. A "cat" whisker is a short wire about five one-thousandths of an inch in diameter. The whisker that is to be used as the collector is made out of a phosphor bronze alloy. The phosphor bronze wire is a good spring and will always exert plenty of pressure on the germanium crystal creating a good contact. During manufacture, a series of electric pulses may be pased between the wire and the germanium crystal resulting in an exceptionally good contact. Beryllium copper is used in the emitter wire because it has good spring qualities and because it forms a very poor contact. The first step in the assembly of a point-contact transistor is the soldering of the germanium crystal to the nickel tab, which is, in turn, connected to the center wire in the glass button.

A "cat" whisker is welded to each outside wire, and with the aid of a microscope and a shadowgraph its point is set on the crystal. The points of the two whiskers are set only a few thoussanths of an inch apart. The whole apparatus is then sealed in a plastic case. Lastly, the collector is pulsed, and the transistor is tested and classified according to its amplification over a specific range of frequencies.

The oblong block which is cut from the double-grown crystal is the basic component of a junction transistor. The assembly of junction transistor is much simpler than that of a point-contact transistor, A wire is soldered to each end and to the middle of the oblong block of germanium. Then the unit is sealed, tested and classified.

A more recent addition to the transistor family is known as the surface barrier transistor. Its manufacture is entirely different from that of either the poin-contact transistor or the junction transistor. Two hair-thin streams of liquid indium salt are squirted against the opposite sides of a thin germanium wafer which has been cut from a grown crystal. Electric current, passed in the streams, slowly eats away at the wafer making it very thin in the center. When the proper thickness has been reached, the current is reversed, and the indium is deposited in the indentations on either side. A wire is fastened to the wafer and to the indium deposited on each side of the wafer. The assembly is then sealed, tested, and classified.

A fourth member of the transistor family is the photo transistor. It is a variation of either point-contact or the junction transistor and is a result of the discovery that light, striking a germanium crystal, produces a current. Several more of the recent additions to the ever-growing family of transistors are: the analog transistor, the unipolar field-effect transistor, the coaxial transistor, the pentode transistor, and the tetrode transistor.

The transistor is rapidly finding uses in all fields of business and especially in those industries connected with radio and television. Point-contact and junction transistors are being used for detection, rectification, and amplification. The photo transistor is the basic element of the electric "eye," whose uses are many and varied. Overall, the transistor shows great promise as a future servant of mankind.

BIBLIOGRAPHY

I. Books

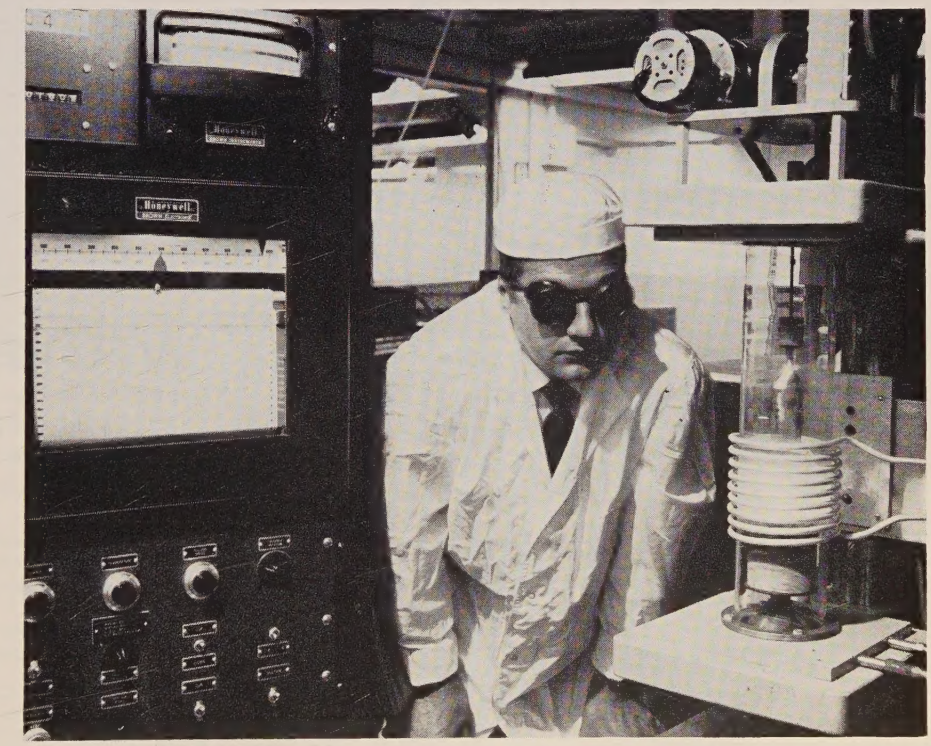
Coblenz, Abraham and Harry Owens. "Transistors Theory and Application." New York: McGraw-Hill Book Co., 1955.

Garner, Louis E. "Transistors and Their Applications in Television, Radio, and Electronics." Chicago Coyne Electrical Engineering School, 1954.

Krugman, Leonard M. "Fundamentals of Transistors." New York: J. F. Rider and Co., 1954.

Malloy, Edward. "Crystal Rectifiers and Transistors." London: Newnes Lmt., 1954.

Pauling, Linus. "College Chemistry." San Francisco: W. H. Freeman and Co., 1955.



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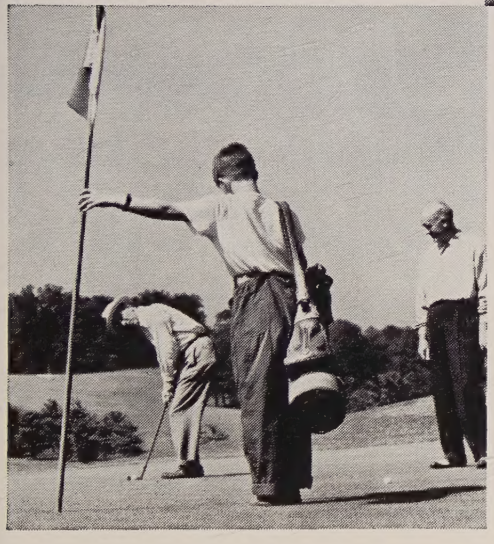

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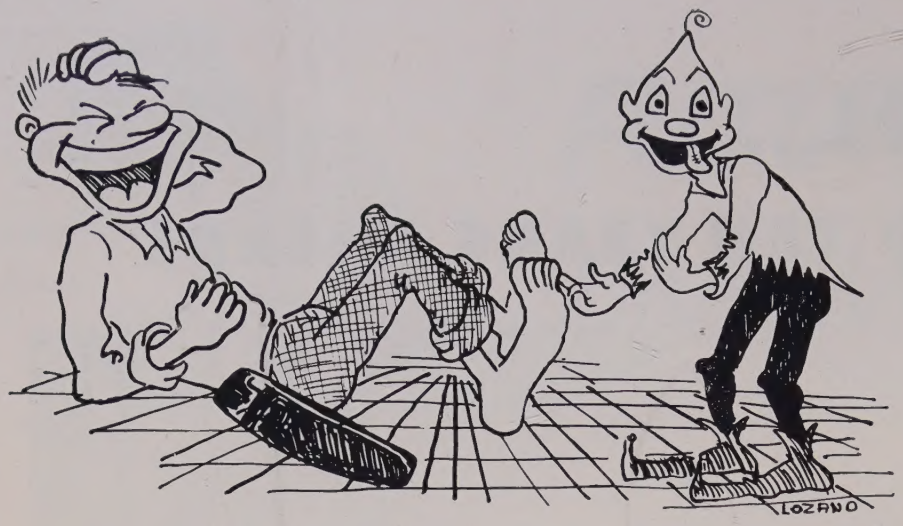

TECHNOCRACKS

R.O.T.C. Sergeant: "Does your uniform fit satisfactorily?"

Frosh: "Well, the jacket is OK, sir, but the pants are a bit snug under the armpits."

* * *

Joe: "How did you get that flat tire?"

Paul: "I ran over a milk bottle."

Joe: "Didn't you see it?"

Paul: "No, it was in the kid's coat pocket."

* * *

A despondent old gentleman emerged from his club and climbed into his limousine.

"Where to, sir?" asked the chauffeur.

"Drive off a cliff, James, I'm committing suicide."

* * *

E.E.: "Want to go steady?"

She: "Oh yes!"

E.E.: "Ever try castor oil?"

* * *

Deciding to teach her drunken husband a lesson, his wife dressed up in a devil's costume. That night when he came staggering home, all lushed up, she met him at the front door. Through his bleary, bloodshot eyes, he looked her all over and said: "Who is in the heck are you?"

"I'm the devil, you sinner."

"Well, I'm sure glad to know you. I married your sister."

* * *

Textbook style: "The puissance of hydrochloric acid is incontestable; however the corrosive residue is inharmonious with metallic persistence."

Ch. E. style: "Hydrochloric acid eats the hell out of steel."

"Give me another pound of your ant powder," said the man rushing into the store.

"I'm glad to see that you like the powder," said the clerk.

"Yes," snapped the customer, "I've got one unconscious with the first pound and I figured I'll be able to kill him with the second."

* * *

Little boy watching milkman's horse: "Mister, I bet you don't get home with your wagon."

Milkman: "Why not?"

Little boy: "Cause your horse just lost all his gasoline."

* * *

M.E.: "Quick, give me a round trip ticket!"

Clerk: "Where to?"

M.E.: "Back here you fool!"

* * *

A Texan, newly arrived in England, was playing poker with a couple of the natives. He was pleasantly surprised upon picking up an early hand to see four aces in it.

"I'll wager a pound," said the Britisher on his right.

"Ah don't know how Y'all measure your money," drawled the Texan, "but Ah reckon Ah'll have to raise yuh about a ton."

* * *

"Halt! Who goes there?"

"British soldiers."

"Pass British soldiers."

"Halt! Who goes there?"

"French soldiers."

"Pass French soldiers."

"Halt! Who goes there?"

"Who in hell wants to know?"

"Pass, Yanks."

The ROTC instructor was never hampered by a sense of false modesty. While duck hunting one time, he spied a bird soaring overhead, took careful aim, and fired, but the bird sailed on undisturbed over the horizon.

The marksman watched in a shocked silence, then dashed his gun to the ground and cried out. "Fly on you blankety-blank fool bird. Fly on with your gol-darned heart shot out!"

* * *

An inmate of the lunatic asylum was to be examined for dismissal. The first question he was asked was: "What are you going to do when you get out of here?"

The inmate replied: "I'm going to get me a slingshot and come back and break every window in this place."

After another six months in the padded cell, he was again examined, and the same question was put to him.

"Well I'm going to get a job," was the reply.

"Fine," said the examiner, "And then what?"

"Then I'm going to buy a big car."

"Good."

"And then I'm going to meet a beautiful blonde."

"Then I'm going to take her out driving on a lonely road."

"Yes."

"Then I'm going to grab her garter, make a slingshot, and come back here and break every window in this place."

* * *

Fellow to blind date: "I never really believed in reincarnation—but what were you before you died?"

* * *

A farmer was phoning a veterinarian. "Say Doc," he said, "I've got a sick cat. He just lays around licking his paws and doesn't have any appetite. What shall I do for him?"

"Give him a pint of castor oil," said the vet.

Somewhat dubious, the farmer forced the cat to take a pint of castor oil. A couple of days later he met the vet in town.

"How's your sick calf?" inquired the vet.

"Sick calf! That was a sick cat I had."

"My gawd, did you give him the pint of castor oil?"

"Sure did."

"Well what did he do?" asked the vet.

"Last time I seen him, said the farmer, "he was going over the hill with five other cats. Two were digging, two were covering up, and one was scouting for new territory."

* * *

"Hard work never killed anyone—but why take a chance on being the first victim?"